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Control of aphids to prevent virus spread in strawberry crops

by H. J. de Fluiter

The following viruses play an important part in Holland in the deterioration of strawberry crops:

1. The mottle virus or, to use our Dutch term "zwak-krinkelvirus", which belongs to the virus complex I of Prentice, a group of non-persistent viruses which remain active in the vector for three hours at the most.
2. The yellow edge viruses which belong to complex II of Prentice; these viruses are capable of remaining active in the vector for several days, in addition to which they are latent in the vector for approximately 24 hours.
3. The "sterk-krinkel" (crinkle) viruses as we term them in Holland, belong to the virus complex III of Prentice, and remain both latent and active in the vector for lengthy periods.

All these viruses are transmitted in our country by the strawberry aphid, *Pentatrichopus fragaefolii* Cock., a pest which is widespread in our strawberry plantations. The abundance of this aphid is one of the prime reasons for the frequent incidence of complex virus infections in Dutch strawberry fields.

Our studies on the population build-up of this aphid have revealed that there are usually 2 periods of marked increase in population density every year; the first period is mostly in June and July, and sometimes extends well into August (first half) while the second period is in September, October and November.

Depending upon the prevailing weather conditions, the summer maximum attaches greater importance in some years, whereas in other years the autumn maximum has greater bearing.

Are these periods of heavy *Pentatrichopus fragaefolii* occurrence also periods of severe virus spread?

In 1955, a large number of field trials were conducted at Bennekom with the object of providing an answer to this question.

In mid-April, a field of about 300 square metres in size was planted with strawberries of the Madame Moutot variety which is severely attacked by strawberry aphid.

On June 3rd, after it had been found that the strawberries were growing well, thirty numbered virus-free and aphid-free potted *Fragaria vesca* plants

were planted in the ground at scattered points of the field between the rows of Mad. Moutot; care was taken that the *Fragaria vesca* plants did not have contact with the Mad. Moutot plants. The wild strawberry (*Fr. vesca*) is an excellent indicator plant for the above-mentioned strawberry viruses.

These *Fr. vesca* plants which had been raised in an insect-free greenhouse of the I. P. O., were left in the test field for two weeks. Then they were dug out and replaced by 30 new *Fr. vesca* plants which, in turn, were also left in the field for 2 weeks and then replaced by 30 other plants. This procedure of rotation was continued from June 3rd until September 2nd when the last batch of *Fr. vesca* plants was placed in the test rows.

After these batches of 30 *Fr. vesca* plants had been exposed for two-weekly periods, they were examined individually for *Pentatrichopus* infestation. The plants were then dipped in a 0.2% nicotine solution to free them of aphids, and subsequently replaced in an insect-free greenhouse where they were examined at regular intervals for incidence of virus symptoms.

At the same time as the check on the *Fr. vesca* plants, the Mad. Moutot plants were also examined for infestation by *Pentatrichopus* aphids (a count was made of the number of aphids on 50 young leaves, which had not yet unfolded, sampled from all over the field).

This method provided information on the following questions:

1. Development of the *Pentatrichopus* population in the Mad. Moutot crop.
2. Degree of *Fr. vesca* plant infestation by *Pentatrichopus* aphids.
3. Degree of virus infection on *Fr. vesca* plants.

Before the results of this test series are discussed, it should be pointed out that at the time they were planted out (mid-April), the Mad. Moutot plants were still free of aphid infestation. A number of *Pentatrichopus* aphids were already found on the Mad. Moutot plants at the start of the test on June 3rd, while in another plantation close to the test field the crop there was already rather severely infested by *Pentatrichopus*.

The prevailing weather during the months of June, July, August and the first part of September was favourable for aphid development (warm and dry). Injury appeared on the strawberry plants, however, during August, as a result of the dry conditions.

The results of the counts carried out in the test field are compiled in Table 1. Column 1 gives the dates on which the counts were made, column 2 the total number of the first aphids counted on 50 young leaves of Mad. Moutot plants (= standard for "infestation" of Mad. Moutot plants), column 3 the average number of strawberry aphids per Mad. Moutot leaf, column 4 the total number of aphids counted on 30 indicator plants, and column 5 the average number of aphids per infested indicator plant. Column 6 includes the total number of aphid-infested indicator plants, column 7 the percentage of *Fr. vesca* plants which were infested by aphids in the preceding period of two weeks, column 8 the number of *Fr. vesca* plants which were infected by viruses in this period of two weeks, and column 9 the percentage of indicator plants infected by viruses.

It is evident from the data in columns 2 and 3 that aphid infestation on Mad. Moutot — stimulated by the good weather from early June onwards — greatly increased at a fast rate, reaching its peak on July 15. Infestation then

Table 1: *Pentatrichopus* and virus spread

1	2	3	4	5	6	7	8	9
Date of evaluation	No. of <i>Pentatrichopus</i> per 50 leaves on Mad. Moutot	Average infestation per leaf	Total no. of <i>Pentatrichopus</i> per 30 indicator plants (<i>Fr. vesca</i>)	Average no. of aphids per infested plant	No. of infested indicator plants	% of total no. of indicator plants	No. of indicator plants infected by virus in the preceding period of 14 days	% of total no. of indicator plants
June 17*	151	3.2	60	4.0	15	50	8	27
July 1	698	14.0	131	5.2	25	83	9	30
July 15*	1370	27.4	300	10.7	28	93	21	70
July 29*	918	18.4	462	16.5	28	93	25	83
Aug. 13*	848	17.0	1020	34.0	30	100	26	87
Aug. 26*	334	6.7	231	8.0	29	96	17	63
Sept. 9	89	1.95	46	2.1	22	73	0	0
Sept. 23	59	1.2	23	2.1	11	36	0	0
Oct. 7*	121	2.4	32	2.0	15	50	0	0
Oct. 21	158	3.1	47	2.8	17	57	0	0
Nov. 4	164	3.3	13	2.1	6	20	0	0
Nov. 17	84	1.7	16	1.6	10	33	0	0
Dec. 2	71	1.4	5	1.25	4	13	0	0

* Dates on which larvae with wing-buds were observed.

decreased somewhat, although it continued to be relatively severe until August 13. From August 13 to 26, there was a marked drop in infestation, followed by an even greater decrease in the period between August 26 and September 9. The obvious reason for this big reduction of the population density is that the feeding conditions on the plants became increasingly less favourable for the aphids owing to the continued period of dry weather. Another factor of major importance, however, which must be given consideration here, is that *Phaenobremia aphidiphora* Rübs. larvae occurred in large abundance and greatly decimated the strawberry aphid colonies. The aphid population continued to remain small from September 9 onwards, except for a slight increase in October and November.

A study of the figures in columns 4, 5, 6 and 7 which deal with the indicator plants, brings to notice the following facts:

1. A big percentage of the first batch of indicator plants — about 50 % — was immediately infested by strawberry aphids, partly by attacking winged individuals but also partly by wingless aphids which migrated into the crop.
2. The infestation of indicator plants by aphids continually increased between June 3 and August 13, as shown by the following observations:

a) Increase in the number of *Fr. vesca* plants colonized by strawberry aphids (columns 6 and 7);

b) Increase in the number of strawberry aphids per plant (columns 4 and 5).

Parallel to these observations, an increasing infection of indicator plants by viruses was observed (cf columns 8 and 9). The greatest spread of aphids, and thus also the greatest dispersal of viruses, took place in the period from July 29 to August 13. The count carried out on August 13 showed all indicator plants to be infested by strawberry aphid. The highest average degree of infestation per plant was recorded on this date, namely 34 aphids per plant, with 87 % of the plants infected by virus.

The infestation of the indicator plants greatly decreased in the following two weeks (from 34 aphids to 8 aphids per plant). But nevertheless, 96 % of the plants were still colonized by aphids, and the percentage of virus-infected plants also remained high (63 %).

There was a sudden drop in the degree of indicator plant infestation after August 26 (the count gave a figure of 2.1 aphids per plant), and no further

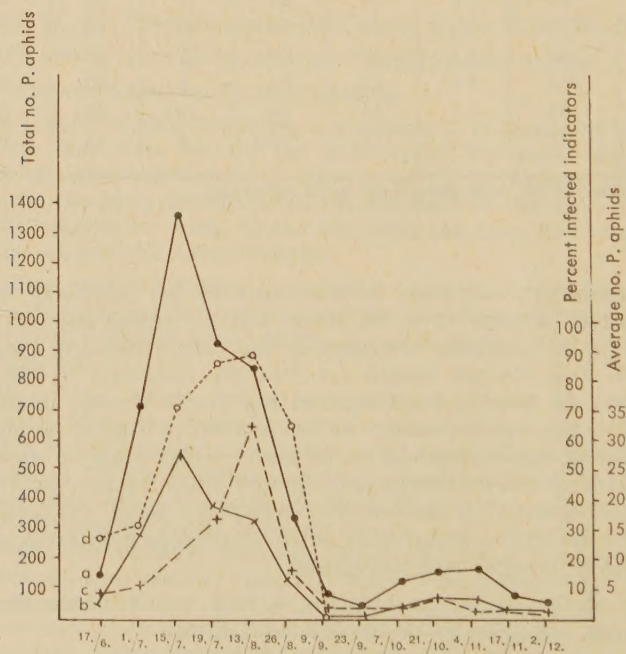


Fig. 1: Trial in Bennekom 1955

- a) ●—● Total no. of *Pentatrichopus* aphids per 50 Mad. Moutot leaves
- b) |—| Average no. of *Pentatrichopus* aphids per Mad. Moutot leaf
- c) ×—× Average no. of *Pentatrichopus* aphids per infested *Fr. vesca* plant
- d) ○····○ Percentage of indicator plants infected by viruses in the preceding two weeks

virus transmission was observed. But at the end of the two-week test period, an appreciable number of indicator plants were still colonized by aphids (cf figures in columns 6 and 7).

It is still not completely certain how this cessation of virus spread can be explained, considering the presence of active, infective aphids.

The simplest explanation is offered by the assumption that the very slight aphid infestation on the indicator plants (2 to 2.8 aphids per plant) must be held responsible for this stoppage of virus spread.

In 1955, the period of virus dispersal fully coincided with the period of increasingly severe aphid infestation on Mad. Moutot plants (cf Fig. 1). The aphid infestation of the indicator plants, and thus the virus infection, too, increased proportionally to the colonization of the Mad. Moutot plants by aphids. This fact again emphasizes how essential it is to carry out an intensive control of aphids in order to prevent a severe infestation during the summer season.

The infection of indicator plants was undoubtedly caused by both alate and wingless *Pentatrichopus* aphids.

When consideration is given to the fact that in our trial, larvae of winged aphids were found on the plants only at sporadic intervals, and that the wingless *Pentatrichopus* aphids are generally very mobile, then we can conclude that these wingless individuals played an important, if not the most important part in the spread of viruses in the plots.

The large spread of viruses in the Mad. Moutot stock was also clearly reflected in the severe incidence of yellow edge which broke out in this plantation in Autumn, 1955 and Spring, 1956.

Experience accumulated in 1956

Although there was still a fairly large abundance of strawberry aphids in the Mad. Moutot plantation at Bennekom in December 1955 (an average of 1.25 aphids per young leaf), this population was almost completely eradicated by the severe frost in February, 1956.

In 1956 the same observations were carried on in this test field as in 1955, except that now batches of 75 indicator plants (*Fr. vesca*) were planted out in the field every two weeks, as against batches of 30 in 1955.

The trial was started on May 23, and ended in December, 1956. During this period, about 1000 indicator plants, in groups of 75, were exposed to infestation and infection in the plots for two weeks.

No strawberry aphids were observed in the field from the start of the test until September 12 on which date the first aphids were seen on a Mad. Moutot leaf. The number of aphids in the stock then grew gradually but the infestation itself remained very slight until December, 1956.

Aphis forbesi and *Acyrtosiphon malvae* subsp. *rogersi*, on the other hand, occurred in fairly abundant numbers on Mad. Moutot plants; the latter species was also generally observed on *Fr. vesca* plants.

Out of the approx. 1000 *Fr. vesca* plants that were planted out in the field in 1956, none showed virus symptoms during the course of the trial, although symptoms of yellow edge — emanating from the 1955 infections — were definitely observed on many Mad. Moutot plants; all these plants were undoubtedly also infected by virus 1.

In 1955, on the other hand, when *Pentatrachopus fragaefolii* Cock. was in abundance, 106 (27 %) of the 390 indicator plants were infected by virus in the period between June 3 and August 26.

More definite proof of the statement that "there is no appreciable spread of strawberry viruses unless *Pentatrachopus fragaefolii* occurs", can hardly be furnished, in my opinion.

Can the spread of strawberry viruses be prevented by controlling the strawberry aphid?

The studies conducted in 1955 and 1956 clearly showed that the *Pentatrachopus* strawberry aphid plays a major part in the spread of strawberry viruses, and therefore 2 large field trials were carried out in 1957 in the area of Wageningen with the object of studying the importance of strawberry aphid control in relation to the dispersal of strawberry viruses.

Test field Bennekom

The first trial was carried out at Bennekom on 3-year-old Mad. Moutot plants which previously had not been treated with crop protection products. The aphid infestation in this plot was at first slight in 1957 (the outcome of the severe winter of 1955—56). The plantation was used in 1957 for propagation, and not for fruiting so that the crop in this test field was not picked.

Test arrangement (see also Fig. 2)

The trial was arranged as a plot test including 3 objects with 5 replications.

Objects:

- a) METHYLDOMETON* 0.1 %, sprayed at two week intervals (plots A1 to A5);
- b) Parathion 25 %; 0.1 %; otherwise as for A (plots B1 to B5);
- c) untreated (C1 to C5).

No. of Mad. Moutot plants per plot: 60.

No. of spray applications: 9.

The first spray application was carried out on May 29, and the final treatment on September 10. The plants were thoroughly wetted so that they dripped. Use was made of a knapsack sprayer.

Evaluation of *Pentatrachopus* infestation

Counting was carried out by the leaf sampling method. Leaves were sampled from ten plants for each count.

Evaluation of virus spread

The incidence of virus was evaluated with the aid of *Fr. vesca* plants acting as indicators. At the start of the test, 10 virus-free and aphid-free

* METHYLDOMETON is marketed under the trade-name of METASYSTOX® in the Federal Republic of Germany and other countries.

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Fr. vesca plants, cultivated in pots, were planted out in each test plot (see Fig. 2). 5 of these plants were set between the rows of Mad. Moutot plants for the purpose of studying the spread of virus from row to row. The other 5 *Fr. vesca* plants were set in the Mad. Moutot rows in order to observe the spread of virus from plant to plant within the rows. These 10 *Fr. vesca* plants (x and — in Fig. 2) served as temporary indicator plants, and were replaced every two weeks by new plants free of virus and aphid infestation; they were then

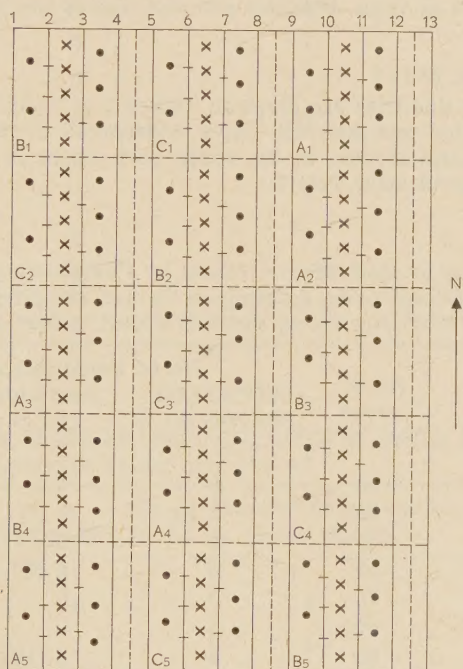


Fig. 2: Test Field Bennekom 1957

- | Rows of Mad. Moutot
- Indicator plants permanently left in field
- × Indicator plants changed periodically between the rows
- Indicator plants changed periodically in the rows
- A₁ to A₅ METHYLDOMETON
- B₁ to B₅ Parathion
- C₁ to C₅ Untreated
- — Plot boundaries
- 1 to 13 Nos. of rows

examined for aphid infestation, subsequently freed of aphids, and afterwards placed in an insect-free greenhouse in Wageningen where they were kept under observation for outbreak of virus symptoms. The first group of temporary indicator plants was set on May 21, and the last group was planted out on September 10. The *Fr. vesca* plants in the treated plots were not sprayed.

Apart from these 10 temporary indicator plants replaced at regular intervals, 5 permanent indicator plants were set in each plot on June 21. These plants were planted in the ground and not in pots, and were left in the plots for the whole of the season. They were also sprayed together with the stock of Mad. Moutot strawberry plants, and were examined on the spot every week for symptoms of virus.

By observing the temporary indicator plants which were replaced by new batches at regular intervals, we were able to gain some indication of the periods in which virus spread takes place. The permanent indicator plants gave an impression of virus dispersal per plot during the whole season.

Results of the trial

The results of this trial are given in Tables 2 to 7. At the start of the test the strawberry aphid was generally more widespread in the north part of the test field (plots 1 and 2) than in the south part where it did not occur on a perceptible scale until after July 2.

Table 2: Infestation of Mad. Moutot plants by *Pentatrichopus fragaefolii* Cock. in the different plots, determined by leaf sampling method (10 leaves per plot; 50 young leaves per test object; 1 leaf per plant).*

Date of sampling	No. of leaves	No. of <i>Pentatrichopus</i> aphids		
		METHYLDEMETON 0.1 %	Parathion 0.1 %	Untreated
June 7, 1957	50	0	1	0
June 18	50	2 (1)	8 (?)	40 (?)
July 2	50	0	0	23 (9)
July 16	50	0	2 (2)	14 (6)
July 30	50	0	0	23 (15)
Aug. 13	50	1	0	46 (22)
Aug. 27	50	0	2 (1)	127 (34)
Sept. 10	50	0	2 (2)	132 (42)
Oct. 1	50	0	3 (2)	134 (39)
Total	450	0	18 (± 7)	539 (± 167)

* The figures in brackets give the numbers of plants on which *Pentatrichopus* aphids were found.

Table 3: No. of virus-infected permanent indicator plants.

Object	Untreated	METHYLDEMETON 0.1 %	Parathion 0.1 %
No. of virus-infected plants	11 (= 44 %)	1 (= 4 %)	6 (= 24 %)

Table 4: Dates on which permanent indicator plants showed symptoms of virus infection.

Date	No. of plants showing virus symptoms		
	Untreated	METHYLDEMETON 0.1 %	Parathion 0.1 %
July 7, 1957	2	1	0
July 16	2	1	0
July 24	6	1	2
July 30	6	1	2
Aug. 7	7	1	2
Aug. 13	8	1	2
Aug. 27	9	1	3
Sept. 3	11	1	5
Sept. 19	11	1	5
Oct. 1	11	1	6

Table 5: Infestation of the 25 temporary indicator plants (set between rows) by *Pentatrichopus* aphids per count.*

Date	No. of <i>Pentatrichopus</i> aphids found		
	METHYLDEMETON 0.1 %	Parathion 0.1 %	Untreated
June 4, 1957	0	0	0
June 18	1	1	4 (3)
July 2	2 (2)	1	1
July 16	0	0	4 (3)
July 30	1	0	1
Aug. 13	0	0	31 (10)
Aug. 27	1	0	14 (6)
Sept. 10	0	0	11 (8)
Oct. 3	0	1	15 (6)
Total	5 (5)	3 (3)	81 (38)

* The figures in brackets give the numbers of plants on which *Pentatrichopus* aphids were found.

Table 6: Infestation of the 25 temporary indicator plants by *Pentatrichopus* aphids.*

Date	METHYLDEMETON 0.1 %	Parathion 0.1 %	Untreated
July 2, 1957	0	1	14 (5)
July 16	2 (1)	7 (1)	6 (3)
July 30	2 (1)	2 (1)	2 (2)
Aug. 13	0	0	28 (11)
Aug. 27	4 (1)	0	13 (9)
Sept. 10	0	0	10 (6)
Oct. 3	0	0	53 (14)
Total	8 (3)	10 (3)	126 (50)

* The figures in brackets give the numbers of plants on which *Pentatrichopus* aphids were found.

Table 7: No. of temporary indicator plants infected by virus per test period.

Period	Untreated		METHYLDEMETON 0.1 %		Parathion 0.1 %	
	a	b	a	b	a	b
May 21 — June 4		0		0		2
June 4 — June 18		0		0		0
June 18 — July 2	1	1	0	1	1	0
July 2 — July 16	0	0	0	0	0	0
July 16 — July 30	0	0	0	0	0	0
July 30 — Aug. 13	3	3	0	0	0	0
Aug. 13 — Aug. 27	2	1	0	0	0	0
Aug. 27 — Sept. 10	3	2	0	0	0	0
Sept. 10 — Oct. 1	5	5	0	0	0	0
Total	14	12	0	1	1	2
	26		1		3	

a = Indicator plants in the rows (see Fig. 2)

b = Indicator plants between the rows (see Fig. 2)

Later the aphids gradually spread over the whole field, and the degree of infestation per plant also increased (see Table 2). The infestation in the test field, however, remained at a relatively low level throughout the season. For this reason, the total values of the five replications have been given per object and per count in Tables 2—7.

The following conclusions are drawn from the tabulated data:

1. Although the strawberry aphid was already observed in the test field in early June, it was not until after the beginning of August that infestation spread at an increasing rate (see Table 2, col. 5).
2. The increase of aphid infestation in the untreated Mad. Moutot plots again corresponded, as in 1955, with the number of Mad. Moutot plants colonized by aphids, and also with the number of permanent and temporary indicator plants infected by virus (see Tables 4 and 7).
3. The spread of viruses continued from mid-June until well into autumn (see Tables 4 and 7).
4. Treatment of the plants at two week intervals with the systemic product METHYLDEMETON 0.1 % or with the non-systemic product Parathion 0.1 % gave very good control of *Pentatrichopus* aphid. Due to its longer residual effect and its systemic action, METHYLDEMETON produced better results than Parathion (see Table 2, col. 3 and 4).
5. The same is noted from Tables 3, 4 and 7 in which the results express the effect of the sprays on the dispersal of virus. The number of infected permanent indicator plants is notably less in the treated plots than in the untreated plots. An especially good result was obtained in those plots sprayed with 0.1 % METHYLDEMETON. Here, only one out of 25 indicator plants was infected by virus.
6. No significant differences were established with respect to aphid colonization and virus infection between the indicator plants set in the rows and those planted out between the rows (see Tables 5, 6, 7).

Test field Wageningen (Fig. 3)

The second large-scale field trial was carried out at Wageningen

Varieties

The test field was divided up into 5 blocks each measuring 200 square metres, and planted with the following varieties:

Deutsch Evern (approval grade E, virus-free)

Mad. Moutot (approval grade AA, not virus-free)

Climax (due to leaf discolorations in spring, classified in grade AA, but nevertheless virus-free)

Ober-Schlesien (approval grade AA, not virus-free)

Jucunda (JK₂, JO₄ and JE₅; approval grade AA, not virus-free).

Each 200 square metre block was set with about 1000 plants in the first ten days of April.

The whole plantation was treated as a seed production field.

Objects

In this series, a trial control of aphid was carried out with 3 objects and 5 replications. The objects were the same as for the trial at Bennekom:

1. Untreated
2. Parathion 25 ‰, 0.1 ‰; treatment at intervals of two weeks.
3. METHYLDEMETON 0.1 ‰; treatment at two week intervals.

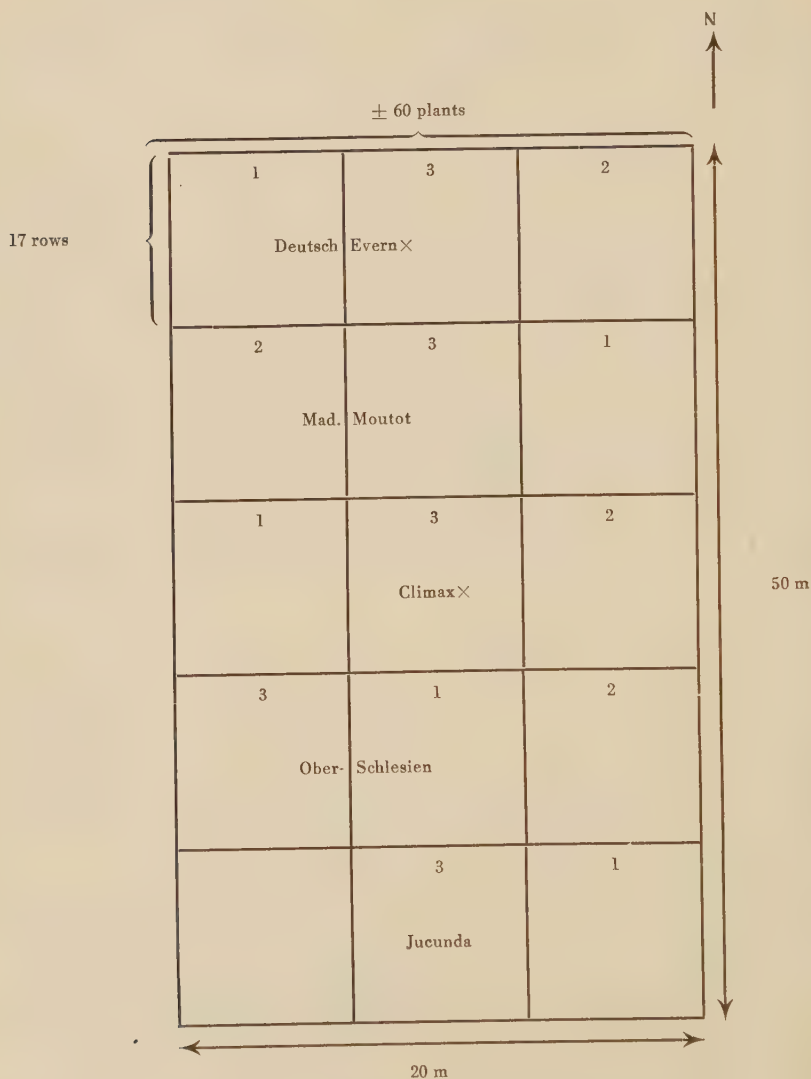


Fig. 3: Lay-out of strawberry test field at Sanoer, 1957

× virus-free

1) untreated

2) Parathion 25 ‰, 0.1 ‰; treatment at two week intervals

3) METHYLDEMETON 0.1 ‰; treatment at two week intervals

No. of plants per test plot: ± 340 .
 First spray application on May 31.
 No. of spray applications: 9.
 Final treatment on September 19.
 Plants sprayed "dripping wet" in each treatment by means of a knapsack sprayer.

Evaluation of trial

Infestation by strawberry aphid was evaluated by means of the leaf sampling method (10 plants were examined per plot, corresponding to 50 plants per object).

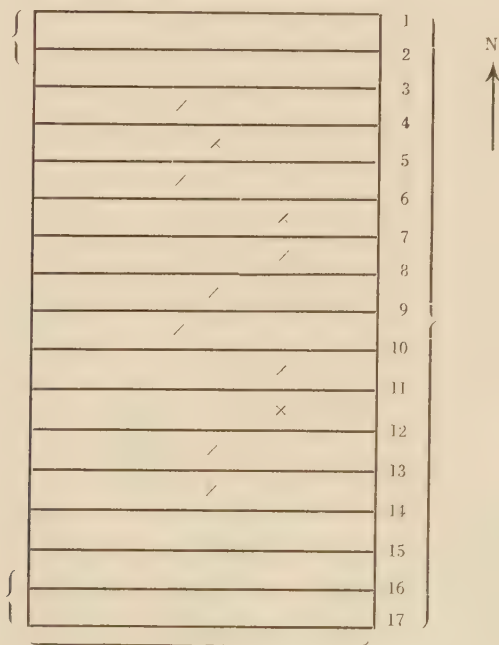


Fig. 4: Plots in Wageningen test, 1957

1 to 17 rows of cultivated strawberries

× permanent indicator plants

Studies of virus spread

11 *Fr. vesca* plants, serving as permanent indicators, were planted out in the soil between the rows of cultivated strawberries, in each plot. In those plots where the cultivated strawberries were sprayed with insecticides, the indicator plants were treated as well.

The 11 permanent indicator plants were set in the test plots on May 24 according to a definite plan (see Fig. 4).

Table 8:

Date of sampling	Object	Variety*					Total no. of aphids
		D. Evern	Mad. Moutot	Climax	Ober-Schlesien	Jucunda	
June 13, 1957	Untreated ** Parathion *** METHYLDOMETON +	2 (?) 0 0	32 (?) 0 0	2 (?) 0 0	0 2 (?) 0	3 (?) 0 0	39 (?) 2 (?) 0
June 27	Untreated Parathion METHYLDOMETON	4 (3) 1 (1) 0	152 (10) 5 (1) 0	7 (4) 1 (1) 0	3 (3) 0 0	14 (6) 0 4 (3)	180 (26) 7 (3) 4 (3)
July 10	Untreated Parathion METHYLDOMETON	5 (3) 2 (1) 0	59 (10) 10 (4) 7 (3)	14 (8) 1 (1) 0	2 (2) 0 0	10 (5) 2 (1) 6 (4)	90 (28) 15 (7) 13 (7)
July 24	Untreated Parathion METHYLDOMETON	6 (5) 7 (2) 1 (1)	45 (10) 1 (1) 0	20 (9) 0 0	11 (4) 0 1 (1)	7 (5) 0 0	89 (33) 8 (3) 2 (2)
Aug. 7	Untreated Parathion METHYLDOMETON	13 (5) 0 0	64 (10) 0 0	31 (10) 0 0	13 (8) 0 0	19 (6) 0 0	140 (39) 0 0
Aug. 21	Untreated Parathion	19 (7) 0	66 (10) 0	26 (6) 1 (1)	42 (10) 1 (1)	43 (10) 1 (1)	196 (43) 3 (3)

	Parathion METHYLDDEMETON	0 0	0 0	0 0	0 0	0 0	12 (1) 0
Sept. 19	Untreated Parathion METHYLDDEMETON	23 0 0	(7)	62 (10) 0 0	25 (6) 0 0	32 (7) 0 0	34 (8) 0 0
Oct. 1	Untreated Parathion METHYLDDEMETON	30 0 0	(9)	48 (9) 0 0	24 (9) 0 0	44 (8) 0 0	27 (9) 0 0
Nov. 8	Untreated Parathion METHYLDDEMETON	63 (10) 0 0	(10)	152 (10) 0 0	39 (8) 0 0	57 (9) 0 0	67 (10) 0 0
Nov. 19	Untreated Parathion METHYLDDEMETON	39 5 (1) 0	(9)	146 (10) 0 0	17 (8) 0 0	21 (8) 0 0	25 (8) 0 0
Total	Untreated Parathion METHYLDDEMETON	215 (±64) 15 (5) 1 (1)	(7)	870 (>99) 16 (6) 7 (3)	218 (±74) 3 (3) 0	265 (68) 15 (±3) 1 (1)	300 (±78) 3 (2) 10 (7)

* The figures in brackets give the numbers of plants on which aphids were found at the counts.

** Untreated *** Parathion 25 %, 0.1 % + METHYLDDEMETON 0.1 %

Table 9: No. of permanent indicator plants infected by virus per object, per plot and per variety during the season

Date	No. of indicator plants with virus symptoms/Total no. of indicator plants											
	D. Evern virus-free			Mad. Moutot not virus-free			Climax virus-free			Ober-Schlesien not virus-free		
	0	par	ms	0	par	ms	0	par	ms	0	par	ms
June 13, 1957	0/11	0/11	0/11	0/11	0/11	0/11	0/11	0/11	0/11	0/11	0/11	0/11
June 27	0/11	0/11	0/11	2/11	0/11	0/11	0/11	0/11	0/11	0/11	0/11	0/11
July 2	0/11	0/11	0/11	2/11	3/11	0/11	0/11	0/11	0/11	1/11	1/11	0/11
July 10	0/11	0/11	0/11	6/11	4/11	0/11	0/11	0/11	0/11	1/11	1/11	0/11
July 19	0/11	0/11	0/11	9/11	4/11	0/11	0/11	0/11	0/11	1/11	1/11	0/11
July 24	0/11	0/11	0/11	11/11	4/11	1/11	0/11	0/11	0/11	2/11	1/11	0/11
July 30	0/11	0/11	0/11	11/11	4/11	1/11	0/11	0/11	0/11	2/11	1/11	0/11
August 7	0/11	0/11	0/11	11/11	4/11	1/11	0/11	0/11	0/11	2/11	1/11	0/11
August 13	0/11	0/11	0/11	11/11	4/11	1/11	0/11	0/11	0/11	2/11	1/11	0/11
August 21	0/11	0/11	0/11	11/11	4/11	1/11	0/11	0/11	0/11	2/11	1/11	0/11
September 3	0/11	0/11	0/11	11/11	5/11	1/11	0/11	0/11	0/11	5/11	3/11	0/11
September 10	0/11	0/11	0/11	11/11	5/11	1/11	0/11	0/11	0/11	5/11	3/11	0/11
September 19	0/11	0/11	0/11	11/11	5/11	1/11	0/11	0/11	0/11	7/11	3/11	0/11
October 1	0/11	0/11	0/11	11/11	5/11	1/11	0/11	0/11	0/11	9/11	3/11	0/11
November 6	0/11	0/11	0/11	11/11	6/11	1/11	0/11	0/11	0/11	11/11	4/11	0/11

*** ms = METHYLDOMETON 0.1 %

* 0 = Untreated

** par = Parathion 25 %, 0.1 %

The total number of 165 indicator plants set in this test field were examined every week for symptoms of virus infection.

During the course of the season, the degree of *Pentatrachopus* infestation on these indicators was also determined at various times per plot, by means of the leaf sampling method.

Trial results

The results of the above-mentioned counts are given in Tables 8 and 9. The following conclusions are drawn from these tabulated data:

1. *Pentatrachopus* aphids are found on all varieties in the control plots already in the first half of June. The worst infestation was on the Mad. Moutot variety; in fact all the plants of this variety were colonized by strawberry aphid by the latter half of June. Infestation gradually increased from early June onwards also on other varieties. All the control plots were infested by strawberry aphid by mid-August.
2. The good effect of the aphid control with Parathion 25 %/o, 0.1 %/o and METHYLDOMETON 0.1 %/o is very clearly indicated by the results in Table 8. A total of 1868 *Pentatrachopus* aphids were counted at 11 counts in the five untreated plots. At this time, about 383 plants were found which were infested by this aphid. The comparable figures for the Parathion plots were 52 aphids and $\pm$ 19 infested plants, and for the METHYLDOMETON plots 19 aphids and 12 infested plants.
3. The bearing of strawberry aphid control on the dispersal of viruses is clearly demonstrated by the results in Table 9. In the untreated plots, *Fr. vesca* plants set in blocks which were planted with cultivated varieties that were not virus-free (Mad. Moutot, Ober-Schlesien, Jucunda), were very soon exposed to virus infection. In the Mad. Moutot plot, definite symptoms of virus infection were visible on all the *Fr. vesca* plants already by July 24. In the Jucunda plot, symptoms of virus infection were clearly perceptible on about half of the indicators on July 19, and all the indicator plants were infected by the end of August. In the Ober-Schlesien plot, the indicator plants became infected more slowly than in the other plot, although here, too, they were all infected in time. The spread of virus was definitely checked in the plots treated with Parathion and METHYLDOMETON, the best effect being given in the plot treated with the systemic product METHYLDOMETON.

In this latter plot, only 4 of the 33 indicator plants became infected by virus throughout the season. A much larger number of indicator plants became infected by virus in the plot treated with Parathion, symptoms of virus infection being apparent on 15 out of the 33 indicator plants towards the end of the test. The reason for this difference is undoubtedly that Parathion does not have a systemic action, and furthermore its residual effect is much shorter.

4. In the test blocks which were planted with the virus-free cultivated strawberry varieties Deutsch-Evern and Climax, not a single indicator plant was infected by virus, despite the fact that the *Pentatrachopus* aphid had soon become almost generally (Deutsch-Evern) or generally (Climax) widespread in the untreated plots (see Table 8). The aphids were usually found also

on the indicator plants in these plots where, however, no source of virus infection was present.

5. The results of the large-scale field trial completely agree with those obtained in the field trial at Bennekom which was conducted on a smaller scale.
6. It may be concluded from the results we have available that the spread of virus infection in both tests was primarily brought about by wingless *Pentatrachopus* aphids, at least in 1957. If winged *Pentatrachopus* aphids had played a leading part in this spread of virus infection, then the indicator plants in the untreated plots of the Deutsch-Evern and Climax varieties (test at Wageningen) would also have been infected by virus, which, however, was not the case.
7. It is obvious from these tests that dispersal of virus can be largely avoided or in fact completely prevented on plants grown for propagation and selection, provided the plants are regularly treated with a systemic product.

The fact that systemic products can also be successfully applied on fruiting plants, is evident from the spraying schedule drawn up by the author in cooperation with Dr. A. F. H. Besemer (Crop Protection Service, Wageningen), which was published in another paper (De Fluiter, 1958).

Control of *Pentatrachopus* aphid

The strawberry aphid can be successfully controlled for the following reasons:

1. This aphid species is very susceptible to certain insecticides.
2. In Holland, it lives in the field solely on cultivated strawberries, and not on other cultivated plants or wild plants. A control operation against strawberry aphid organized on a regional basis, and in which all strawberry growers take part, must, therefore, lead to a big reduction of the strawberry aphid population in the strawberry stocks, and thus also to a big decrease in the incidence of virus infection.

The control of *Pentatrachopus* aphid in strawberry stocks must become a permanent part of the spraying schedule.

The control of this aphid species attaches increasing importance as more virus-free plant material is placed on the market.

Spraying technique

Spraying should be carried out by means of a knapsack sprayer or a motor-powered sprayer. It is essential that the heart of the plant is thoroughly wetted, because usually most of the aphids are concentrated there. An adequate volume of spray solution should be applied (800 to 1000 litres per hectare, and even more if necessary, especially when the stock is severely infested). Atomizing has been found to give less favourable results than spraying.

The control of *Pentatrachopus* aphid can be combined with the control of other insect pests or diseases, so that it need not constitute an extra burden on growers who already have a fixed spraying schedule.

The applications against aphids can be coupled with a spray application of wettable sulphur against mildew, or with a TMTD spray against *Botrytis*, or with a treatment directed against strawberry blossom weevil, strawberry rhynchites, leaf eating weevils, caterpillars and bugs. In such cases, the use of wettable powder is recommended.

Growers are advised against using emulsions because of the risk of causing leaf burns.

Several general recommendations

Finally, a few general recommendations are given for the information of growers:

1. Keep selection and propagation plots always separate from plots of fruiting plants because there is always the danger that fruiting plants carry virus infection.
2. As far as possible, plant only virus-free strawberries or plants of the approved grade.
3. Do not take planting material out of your own plantation, unless virus-free planting material has been used — because one's own plants are always infected.
4. Only use aphid-free plants or spray the plants as soon as they have taken root with an effective aphicide, preferably a systemic product.
5. Carry out thorough controls of *Pentatrichopus* aphid in all strawberry plantations, always bearing in mind that:
„No *Pentatrichopus* aphids means no spread of virus infection!“

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The maize stalk borer (*Busseola fusca* Fuller) and its control in South Africa

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Maize* is the most important crop grown in the Union of South Africa, the annual production having a value of approximately 50 million pounds sterling. The maize stalk borer (*Busseola fusca* Fuller) is causing more damage to maize than any other pest and it has been estimated that on an average this insect destroys about 10 % of the crop. It is therefore understandable that this pest has been given considerable attention during recent years.

The maize stalk borer has so far only been recorded in Africa. It occurs mainly on maize throughout the Union of South Africa, but is also found on kaffircorn (*Sorghum* spp.) as well as on several indigenous grasses. It is also an important pest of maize in the Central African Federation, East Africa and Nigeria, and has been reported from Nyasaland, the Belgian Congo and Angola (Mally, 1920).

Biology. The adult stage of the maize stalk borer is a moth about five-eighths of an inch long, deep cream in colour with small dark markings on the wings. The moths fly mostly in the evenings and early mornings and are not attracted by light. During spring, from October to December, whenever conditions are favourable, the moths lay their eggs in batches of 150 at a time in the leaf axils or leaf whorls of the young maize plant. Each moth may lay up to 800 eggs during its life time. The eggs are pearly white in colour and about 0.5 mm. in size and hatch in 8 to 10 days. After hatching, the young caterpillars are about one-twelfth of an inch in length, light in colour with a pinkish tinge, the head being shiny black. They crawl up the leaves and down inside the funnels into the heart of the plant where they feed on the soft layers of leaves. The caterpillars continue to feed in the funnel for about 10–14 days until they have developed sufficiently to penetrate into the stalk. Often caterpillars migrate from the original host plant to adjacent plants and start secondary infestations. In the last instar the caterpillar has a creamy white colour and a reddish-brown head and measures over one inch in length. When they have penetrated into the stalk the caterpillars feed on the pith and eventually pupate low down in the stalks. The pupal stage lasts about 10–14 days after which the moths of the second generation appear.

There are usually two but often three generations per year depending on climatic conditions. At the onset of winter, caterpillars of the 2nd or 3rd generation which have not pupated yet bore down the stalk to below soil surface and hibernate there for the remainder of the winter. During the following spring they pupate and develop into moths and start the cycle again.

When the maize plants are about 12" high, the first sign of a stalk borer infestation is usually noticed. The leaves then have a speckled or spotted appearance due to the feeding of the young caterpillars in the funnel. In cases of severely infested plants the leaves turn white or appear pleached. The feeding of the caterpillars in the stalks weakens the plant with the result that

* Zea maize

it is easily blown over by wind. Often the growing tip is severely damaged so that the plant remains stunted and may eventually die. Should plants escape infestation by first generation borers and reach full maturity, the ears may be subjected to such a devastating second and third generation infestation as to make them worthless. (Mally, 1920, du Plessis, 1943).



Fig. 1: Typical symptoms of stalk borer damage to young maize

Methods of Control. Many methods of controlling the maize stalk borer have been employed in the past. Control measures during winter aim at exposing and dessicating the caterpillars hibernating in the stalks. This may be achieved either by grubbing out the stalks and cutting them to pieces with suitable farming implements or ploughing them into the soil to a depth of at least 6 inches where they decompose resulting in destruction of the caterpillars.

In the short period of 10—14 days during summer when the caterpillars are feeding in the funnels, and before they enter the stalks, it is possible to control them by means of insecticides. Only this aspect of control will be dealt with in detail in this paper.

Insecticides and their Application. Stalk borers can be controlled by various insecticides if brought into contact with them whilst feeding in the funnels. The difficulty in practice however, has been to deposit sufficient insecticide at the feeding points. Dichlorodiphenyltrichloroethane, formulated as a 2.5 % or 5 % dust, has been used to some extent for maize stalk borer control in the past. A small amount of the dust is applied manually with a suitable scoop or shaker to the funnel of each plant but the effectiveness of this method is offset by the time required for application. One labourer can only treat about 3 morgen* of maize per day and consequently a large labour force is required to treat the fields within the limited period of about two weeks during which the plants must be treated. Sufficient labour is however not always available and many farmers were unable to treat all their lands and often carried out no treatment at all.

Application of Dichlorodiphenyltrichloroethane by mechanical dusters has proved unsatisfactory for the control of maize stalk borer. The reasons for this are that insufficient amounts of the insecticide are deposited in the funnels and furthermore under natural conditions the funnels of many plants are obscured by outer leaves and so escape treatment.

Spraying with low volume equipment results in erratic control since the insecticide does not reach all the funnels or penetrate sufficiently deep. The transport of large amounts of water required for spraying is a further disadvantage. From the foregoing it is obvious that there is a need for an effective insecticide which can be applied mechanically thus enabling the speedy and economical treatment of large areas of maize. The question of residues is important in the case of maize since it is often used for green silage and fed to cattle and other animals. For this reason Dichlorodiphenyltrichloroethane cannot be used for this purpose.

Tests with DIPTEREX® Granulate. DIPTEREX also known as Bayer L 13/59, is one of the most promising insecticides developed during recent years. Chemically Bayer L 13/59 is Dimethyl-hydroxy-trichloroethyl-phosphonate. This insecticide has been found very effective against various Lepidoptera and Diptera. It has a favourable mammalian toxicity** and no dangerous residues of DIPTEREX are left on crops if applied at the latest 7-10 days before harvest. A most interesting property of DIPTEREX is its ability to penetrate into plant tissue and so control hidden pests. The particular properties of DIPTEREX indicated that this preparation may be suitable for the control of maize stalk borer, and tests were commenced during November 1956.

Preliminary experiments conducted with 1.76 pints (1 litre) of DIPTEREX 50 % emulsion per morgen, applied by low volume spray equipment, showed a measure of control against maize stalk borer but generally the results could not be considered satisfactory. The failure of the emulsion to give consistently good results is also attributed to the limitations of low volume spray equipment and no further experimental work was undertaken with the emulsion. However, other formulations of DIPTEREX were investigated.

* 1 South African morgen = approximately 0.9 Hectare.

® = Registered trade mark of Farbenfabriken Bayer Aktiengesellschaft, Leverkusen

** LD 50 to rats orally = 625 mg/kg (Schulemann, 1955).

Recently granular insecticides have been developed, particularly in the U.S.A., since they have been found superior to other formulations for the control of certain pests. Although there was no information available on the effectiveness of DIPTEREX in granular form at the time when this work was commenced it was thought that a granular formulation may be suitable. The particles of a granular insecticide are heavier and larger than those of a dust and they do not stick to the foliage but roll down into the leaf axils and funnels and would enable the greater part of the insecticide to reach the feeding points of the caterpillars. Furthermore, granular formulations can be applied to the rows only, which makes it possible to effect a saving in the material to be applied per morgen.

In the course of preliminary investigations a number of different formulations containing various types of kaolin and talc carriers were tested. It was found that not only the type of carrier and the way in which the granulate was formulated, but also the particle size influenced the biological efficacy of the final product. This is illustrated by the experimental results presented in Table 1.

Mechanical Application. After having established the most suitable type of granular formulation of DIPTEREX, a number of large scale field tests were carried out using two different types of mechanical applicators:

1. The "Gandi Hi-Lo Chemical Applicator" (Figs. 2 and 3) consists of a hopper from which the material is fed by gravity through a series of holes in the bottom of the hopper. The applicator can be adjusted to release the granulate in a band 9—12 inches wide over the rows only.
2. The „Nico Duster“ (Fig. 4) is, as the name implies, designed for the application of dusts. The material is force-fed by means of a blower through four fish-tailed spouts connected to flexible hoses which can be adjusted according to the width of the rows. The duster is mounted on the rear of a tractor and operates from the power take-off shaft. The height of the spouts can be adjusted to give a band of granulate 9—12 inches wide.

Both applicators can treat two or four rows simultaneously depending on whether the rows are 7 or 3 ft. apart and also the rate of application can be varied. Each of the applicators can treat over 45 morgen of maize per day.

In tests carried out with both applicators, DIPTEREX Granulate 2.5 % provided excellent control of the maize stalk borer at the rate of 18 lbs. (7 ft. spacing) and 15 lbs. (3 ft. spacing) per morgen. Under windy conditions the Nico Duster showed certain advantages over the Gandi Hi-Lo Applicator insofar as it forced the material down to the funnels and less loss due to drift was experienced. Numerous tests were carried out under different conditions during the period 1956—58 and the one described below may be taken as a typical example.

In December 1957, DIPTEREX Granulate 2.5 % was applied at a rate of 18 lbs. per morgen with the Nico Duster to 2½ morgen of maize planted in 3 ft. rows standing between 24 and 48 inches high on the Emmesdale Agricultural School farm, Heidelberg, Transvaal, where an estimated 15 % infestation occurred. Three days after treatment, 25 plants were chosen at random and dissected to determine the degree of control. The results recorded are given in Table II.



Fig. 2



Fig. 3

Figs. 2 and 3: The Gandhi Hi-Lo Chemical Applicator

Table 1: Effect of Different Formulations of DIPTEREX Granulate on Maize Stalk Borer. Treatment carried out on the 27.12.1957. Plants dissected and examined on the 31.12.1957.

Plant No.	Formulation 1 25 lb./morgen			Formulation 2 20 lb./morgen			Formulation 3 18 lb./morgen			Formulation 4 25 lb./morgen			Formulation 5 23 lb./morgen		
	Dead	Mori- bund	Alive	Dead	Mori- bund	Alive	Dead	Mori- bund	Alive	Dead	Mori- bund	Alive	Dead	Mori- bund	Alive
1	2			6			4			1			2		
2	2		1	4			2			3			3		
3	2			2			6			1			1		1
4	6			3			2			1			1		
5	9			11			3	1		4			1		
6	5		1	3			1			1			3		2
7	2			6			2			4			2		
8	3			3			5		1	4			2		
9	2			5			3			5			2		1
10	4			2			7			3			3		3
11	2			2			3			1	1		2		1
12	5			4		1	3	1		1			2		1
13	4		1	10			3			3			2		
14	5		1	1		1	4			2			4		
15	2	1		2			7			2			2		1
16	2	1		6			3			3			3	1	
17	2	1	1	2	1		10			4			1	1	
18	2	1	2	2			2			4			1		1
19	2	1	1	6			5			1			6	1	
20	7			2			3			6			2		1
	70	5	8	82	1	2	82	3	1	53	1	29	47	1	13
Percentage mortality *	90			97			99			65			79		

* including moribund larvae

Since the experimental work described above has been completed, DIP-TEREX Granulate 2.5 % has been made commercially available and has been used by a great number of farmers during the 1958—59 season. This large scale use in practice has fully substantiated the results obtained in the experiments and proved that DIPTEREX Granulate is eminently suitable for the control of maize stalk borer when applied by mechanical equipment.

Aerial Application. Aerial application of insecticides is used in many fields of pest control in South Africa. The particular advantages of aerial application are that large areas can be treated rapidly, and that insecticides



Fig. 4 The Nico Duster (experimental arrangement of fish-tailed spouts applying double dosage to centre row)

can be applied under wet conditions when ground equipment is partly or completely immobilized. Bearing this in mind, experiments were undertaken to test the effectiveness and suitability of aircraft application of DIPTEREX Granulate. Aerial application necessarily involves the broadcasting of insecticides as opposed to row application, and the cost of application depends to a large extent on the amount of insecticide which has to be applied per morgen. It was reasoned that a formulation with a high percentage of active ingredient to be

Table 2: Effect of DIPTEREX Granulate 2.5% on maize stalk borer when applied by mechanical means.

Plant No.	Condition of Caterpillars				Plant No.	Condition of Caterpillars			
	Dead	Mori-bund	Alive	Total		Dead	Mori-bund	Alive	Total
1	8	—	—	8	12	4	1	—	5
2	6	1	1	8	13	5	—	—	5
3	15	—	—	15	14	5	—	—	5
4	14	—	—	14	15	10	—	—	10
5	3	—	—	3	16	2	—	—	2
6	4	—	—	4	17	12	3	1	16
7	10	—	—	10	18	4	1	—	5
8	3	1	—	4	19	6	—	—	6
9	16	—	—	16	20	10	1	—	11
10	13	—	—	13	21	5	—	—	5
11	7	1	—	8	22	8	—	—	8
					23	12	—	—	12
					24	9	—	—	9
					25	6	—	—	6

Percentage mortality including moribund larvae 98 %

When 15 plants were again dissected on the 18.12.1957 the percentage mortality had increased to 99 %.

applied at a low rate per morgen would be more economical than a low percentage formulation applied at a high rate. Consequently, a 5 % DIPTEREX Granulate was prepared for this purpose in addition to the 2.5 % formulation used in previous experiments.

A test with these two formulations was carried out in January 1958, on the farm of Messrs. C. Halford & Sons, Pyramids, Pretoria*. Approximately 10 morgen of maize standing 15—25 inches high and planted in 3 ft. rows were treated with each preparation. The degree of infestation was estimated at 5—8 %. The granules were applied in swaths 45 yards wide by a Piper Cub aircraft flying at a speed of 80 m.p.h. and fitted with a Venturi type of fertilizer applicator. At the time of treatment it was partially cloudy, warm with a slight wind blowing. DIPTEREX Granulate 2.5 % was applied at the rate of 43 lb. per morgen whilst the 5 % formulation was applied at 24 lb. per morgen. Three days after treatment the caterpillar mortality in the experimental plots was recorded to determine the efficacy of this method of application. The results are given in Table 3.

* The aerial application was carried out by Mr. T. Hartwanger of Messrs. Boland Air Spray Services Ltd. Many thanks for your kind co-operation.



Fig. 5 : An aircraft fitted with a granulate applicator

Table 3 : Effect of DIPTEREX Granulate 2.5% and 5% on maize stalk borer when applied from aircraft.

Plant No.	DIPTEREX 2.5%			DIPTEREX 5%		
	Dead	Moribund	Alive	Dead	Moribund	Alive
1	13	—	—	2	—	—
2	2	—	2	7	—	—
3	5	—	—	3	—	—
4	8	—	—	5	—	—
5	5	—	—	1	—	—
6	—	—	—	2	1	—
7	2	—	3	1	—	—
8	6	—	—	2	—	—
9	3	—	—	4	—	—
10	6	—	—	1	—	—
11	2	—	—	8	—	—
12	2	—	—	4	—	—
13	3	—	—	2	—	—
14	6	—	—	1	—	—
15	3	—	—	1	—	—
Total	66	0	5	44	1	0

Percentage mortality including moribund larvae:

DIPTEREX Granulate 2.5 % 92 %

DIPTEREX Granulate 5 % 100 %

Summary:

1. The importance, geographical distribution and biology of the maize stalk borer (*Busseola fusca* Fuller) is briefly described.
2. Certain of the methods of control employed up to the present as well as their disadvantages are outlined.
3. Experiments with DIPTEREX Granulate 2.5 % show that this insecticide is suitable for the control of maize stalk borer when applied mechanically.
This method is superior to hand application of Dichlorodiphenyltrichloroethane as large areas can be treated rapidly.
4. The main advantage which a granular formulation offers is that it ensures that more of the insecticide reaches the feeding points of the caterpillars in the funnels of the maize plants.
The granular formulation has the additional advantage that it obviates the necessity of transporting water to the field as required for spray applications.
5. Experiments carried out indicate that DIPTEREX Granulate containing 2.5 % active ingredient may also be successfully applied by aircraft for the control of maize stalk borer.

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A Summary of Field Results with GUTHION^{*R} in North America

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The past decade has witnessed one of the most spectacular revolutions in the history of chemistry and agriculture. Use of chemicals as aids in the production of farm crops is at the highest level ever and indications are that it is ever increasing as newer and more efficient materials are made available.

In the specific field of protection of livestock and plant crops from the ravages of insects and spider mites, the revolution has been no less. Many new

* = 0,0-Dimethyl-S-4-oxo-1,2,3-benzotriazin-3(4H)-ylmethyl-phosphorodithioate, formerly known as Bayer 17147; registered in many countries under the name of Gusathion.
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and useful chemicals have been introduced which have made it possible to produce finer-quality insect-free agricultural commodities.

The most interesting group of insecticidal and miticidal chemicals to be introduced during this time has been the organic phosphates. The rapid and efficient kill of insects and spider mites by chemicals in this group is the primary reason that manufacturers and field research investigators have concentrated their efforts in developing new ones and extending the utility of those already accepted and established.

One of the more useful characteristics of the organic phosphates has been their short residual quality. Growers of high quality fruit and produce have found them tailor-made for situations in which immediate control of pests at marketing time is essential to the sale of the food product. The absence of harmful chemical residues within short intervals of application is an additional and important advantage which causes the organic phosphate chemicals to be much in demand.

There are situations in control of insect pests in which short-term chemical residual is undesirable.

Parathion, synthesized by Dr. Gerhard Schrader, and developed by Farbenfabriken Bayer A. G. of Leverkusen, Germany, has become established as the leading organic phosphate insecticide sold, primarily because of its characteristic, among the phosphates, of longer residual chemical activity against insects and spider mites in addition to a wide spectrum of activity against these pests.

More recently, another organic phosphate insecticide with yet longer residual activity has been introduced. This chemical is GUTHION.

GUTHION is also a development of the laboratories of Dr. Gerhard Schrader and Farbenfabriken Bayer A. G. and it indicates promise of an even wider spectrum of activity for control of insects and spider mites.

The following is intended as a review of field test results obtained with GUTHION by research investigators in agriculture in North America (United States and Canada.)

Though several, highly-effective pesticides have for some time been available for control of important pests damaging cotton, the onset of increasing tolerance of the cotton boll weevil (*Anthonomus grandis* Boh.) (21, 53) in certain areas of intense cotton cultivation to a number of the more commonly used materials spurred interest in the search for new materials specific to this organism. The organic phosphates had long been evaluated as cotton pesticides, but for one reason or another, primarily the short residual qualities, they were never heartily endorsed. These intense efforts revealed that GUTHION has the essential long-term residual qualities necessary for use as a cotton pesticide and that in addition, it has a specificity to the cotton boll weevil at low dosage rates equal or superior to the most effective boll weevil insecticides presently in use (7, 12, 13, 21, 27, 31, 37, 41, 43, 45, 46, 50, 51, 52, 53, 57). GUTHION also has a high degree of specificity to several other important cotton pests. When applied on schedules commonly employed in cotton insect control practices the material consistently provides lowest insect infestations and highest cotton yields. Tests throughout the cotton belt have shown that a dosage rate of four ounces of active material per acre will provide a high degree of protection against the cotton boll weevil (*A. grandis* Boh.), the cotton fleahopper (*Psallus seriatus* Reut.), the cotton leafworm (*Alabama argillacea* Hbn.) and thrips

Frankliniella fusca Hinds, *F. tritici* Fitch), aphid (*Aphis gossypii* Glov.) and mites (*Tetranychus desertorum* Banks, *T. tumidus* Banks, *T. telarius* L., *T. cinnabarinus* Bois.) attacking cotton (2, 14, 17, 18, 19, 27, 31, 42, 45, 50, 57). GUTHION is presently registered for use against these pests. Higher rates, particularly in combination with DDT, have provided effective control of the pink bollworm (*Pectinophora gossypiella* Saund.) (1, 7, 9, 20, 31, 37, 38, 50, 59). Less than two ounces active material per acre has been found to be effective for control of brown cotton leafworm (*Acontia dacia* Druce) (31, 33).

Some concern was expressed for the dangers to agricultural workers and to the general public associated with the large-scale introduction of organic phosphate insecticides to vast acreages of cotton. Specific investigations (47) and the experience of general use of these materials have demonstrated there is no cause for alarm. Though toxic, the organic phosphates have an outstandingly safe record of use on cotton. And, though itself a toxic material, GUTHION has a relatively low skin and inhalation toxicity.

A still greater range of insect control is exhibited by GUTHION on fruit crops. Repeatedly, in extensive tests throughout the areas where fruit is grown, it has shown remarkable effectiveness against a wide variety of pests. Registration for use of the material has been granted on bearing fruits such as apples and crabapples, apricots, peaches, nectarines, quinces and pears. Application of five ounces of active material in one hundred gallons of water is sufficient for effective control of apple aphid (*Aphis pomi* de G.), apple maggot (*Rhagoletis pomonella* Walsh), codling moth (*Carpocapsa pomonella* L.), European red mite (*Panonychus ulmi* Koch), two-spotted mite (*Tetranychus telarius* L.), plum curculio (*Conotrachelus nenuphar* Hbst.), red-banded leaf roller (*Argyrotaenia velutinana* Wlk.), fruit tree leaf roller (*Archips argyrospila* Wlk.), tarnished plant bug (*Lygus lineolaris* P. de B.), stink bugs (*Euschistus* spp.), European apple sawfly (*Hoplocampa testudinea* Klug), and oriental fruit moth (*Grapholitha molesta* Busck.) (4, 6, 11, 25, 35).

In addition to the above registered uses, other recommendations for GUTHION listed by the U. S. Department of Agriculture (62) for control of insect pests on fruit are as follows: On apples, a rate of five ounces of active material is recommended for the control of four-spotted (*Tetranychus canadensis* McG.), McDaniel (*Tetranychus mcdanieli* McG.), Schoeni (*Tetranychus schonei* McG.) and other mites; Forbes (*Aspidiotus forbesi* Johnson), Putnam (*Aspidiotus ancylus* Putn.) and San Jose (*Aspidiotus perniciosus* Comst.) scales; and leafhoppers (not identi.). At two and one-half ounces active material per hundred gallons, it is recommended for control of apple grain aphid (*Rhopalosiphum prunifoliae* Fitch) and rosy apple aphid (*Anuraphis roseus* Baker). For woolly apple aphid (*Eriosoma lanigerum* Hausm.), a rate of seven and two-tenths ounces active material per hundred gallons is recommended.

On cherry, the U. S. Department of Agriculture recommends a rate of eight ounces active material per hundred gallons for control of the lesser peach tree borer (*Synanthedon pictipes* G. and R.).

On peach, the recommended rate for red-banded leaf roller (*Argyrotaenia velutinana* Wlk.), *Platynota flavedana* Clem. (a leaf roller of fruit trees), green peach aphid (*Myzus persicae* Sulz.), black cherry aphid (*Myzus cerasi* F.), black peach aphid (*Anuraphis persicae-niger* Smith), rusty plum aphid (*Hysteroneura setariae* Thomas), Forbes scale (*Aspidiotus forbesi* Johnson), San Jose scale (*A. perniciosus* Comst.) and white peach scale (*Pseudaulacaspis pentagona* Targ.) is five ounces of active material per hundred gallons. A rate of six ounces

active material per hundred gallons is recommended for control of peach tree borer (*Sanninoidea exitiosa* Say) and a rate of eight ounces active material per hundred gallons is recommended for control of the lesser peach tree borer (*S. pictipes* G. and R.) on peaches.

Against pear insects, the U. S. Department of Agriculture recommends the use of five ounces of active material per hundred gallons of spray for the control of Forbes (*Aspidiotus forbesi* Johnson) and San Jose (*Aspidiotus perniciosus* Comst.) scales, two-spotted (*Tetranychus telarius* L.), McDaniel (*Tetranychus mcdanieli* McG.) and related mites. Two and one-half ounces active material per hundred gallons is recommended for the control of apple (*Aphis pomi* D. G.) and apple grain (*Rhopalosiphum prunifoliae* Fitch) aphids on pear.

Five ounces active material per hundred gallons is recommended for the control of Forbes (*Aspidiotus forbesi* Johnson) and San Jose (*A. perniciosus* Comst.) scales on plum and prune. Six ounces active material per hundred gallons is recommended for control of the peach tree borer (*Sanninoidea exitiosa* Say) and seven and two-tenths ounces active material per hundred gallons is recommended for control of the lesser peach tree borer (*S. pictipes* G. and R.) on plum and prune.

No other material used on fruit has this wide range of effectiveness and it is now possible for the grower to obtain control of fruit pests during the season with the use of only one insecticide.

The foregoing is a reflection of the presently registered and recommended commercial uses of GUTHION, which were preceded by several years' field investigations. Simultaneously, field research has been conducted on many other crops and pests and a summary of these investigations follows.

On apple, several other pests appear to be susceptible to applications of GUTHION. Varying results have been obtained against woolly apple aphid (*Eriosoma lanigerum* Hausm.) but its effectiveness at eight ounces active material per hundred gallons appears sufficiently promising to warrant further investigations, particularly studies timed to the life cycle (34). Eight ounces active material per hundred gallons was also effective against a tentiform leafminer (*Lithocolletis* sp.) (35). Results of tests against Forbes scale (*Aspidiotus forbesi* Johnson) at five ounces of active material per hundred gallons indicate GUTHION is effective against this organism. The effectiveness of GUTHION against spider mites on apple has already been established (11). It appears from tests that this effectiveness also carries over to clover mite (*Bryobia praetiosa* Koch) at dosages as low as two and one-half ounces of active material per hundred gallons.

Tests for the control of peach tree borers are also varied. Effective results against both the lesser (*Syanthodon pictipes* G. and R.) and the common (*Sanninoida exitiosa* Say) peach tree borers are reported with repeated applications of eight ounces of active material in one hundred gallons of water as a trunk and lower limb spray.

Against pear psylla (*Psylla pyricola* Förster) highly effective control was obtained with twelve ounces of active material per hundred gallons.

The effectiveness of GUTHION against European red mite (*Panonychus ulmi* Koch) has been demonstrated on prunes and plums and this at the same rate of active content, five ounces per hundred gallons, as is recommended for use on apples, peaches, and other tree fruits. In addition, tests also prove this rate to be effective against leaf rollers (not identi.) on plums. This same rate

has been shown to be highly effective for control of mealy plum aphid (*Hyalopteris pruni* Geof.).

Rather comprehensive tests have shown GUTHION to be effective for cherry maggot (*Rhagoletis cingulata* Loew) and plum curculio (*Conotrachelus nenuphar* Hbst.) on cherry at a rate of eight ounces of active material per hundred gallons with repeated applications. This rate on cherry is also effective for control of fruit tree leaf roller (*Archips argyrospila* Wlk.) and red-banded leaf roller (*Argyrotaenia velutinana* Wlk.).

On sweet and sour cherries, a five ounces active substance per hundred gallons rate effectively controls red-banded leaf roller (*Argyrotaenia velutinana* Wlk.), plum curculio (*Conotrachelus nenuphar* Hbst.), cherry fruit fly (*Rhagoletis cingulata* Loew) and black cherry aphid (*Myzus cerasi* F.). On sweet cherry, eight ounces of active material per hundred gallons effectively controls plum nursery mite (*Vasates fockeui* Nal.) (3).

Against pests of various citrus fruits GUTHION appears to provide effective control. One report indicates control of fruit tree leaf roller (*Archips argyrospila* Wlk.) with twenty-four ounces of active material per acre on navel oranges. Another report indicates effective control with twenty ounces active per acre. A lesser rate is probably effective as on apple and pear. Fourteen ounces of active per hundred gallons effectively controls soft brown scale (*Coccus hesperidum* L.). One and two ounces active per hundred gallons were not highly effective against green citrus aphid (*Aphis spiraecola* Patch); a higher concentration is indicated. Eight ounces active per hundred gallons of spray provides good control of citrus flower thrips (*Frankliniella cephalica* Craw.). Four ounces of active material in one hundred gallons of spray is reported effective for control of both citricola (*Coccus pseudomagnoliarum* Kuwana) and cottony cushion (*Icerya purchasi* Mask.) scales attacking navel oranges and lemons. At sixteen ounces of active per acre, GUTHION is effective against western tussock moth (*Hemerocampa vetusta* Bdv.) (5), but less effective against orange tortrix (*Argyrotaenia citrana* Fern.) on navel and Valencia oranges. Thirty-two ounces active material per acre was the rate used for effective control of orange tortrix. Against Baker's mealybug (*Pseudococcus maritimus* Ehrh.), three ounces active per hundred gallons was effective. Six ounces of active material per hundred gallons of spray is reportedly providing good control of citrus whitefly (*Dialeurodes citri* Ashm.). In one test, a rate equivalent to two ounces active per hundred gallons in a kerosene solution provided effective control of California red scale (*Aonidiella aurantii* Mask.) on lemon (16).

Results from tests with GUTHION on grapes indicate effective control of grape leafhopper (*Erythroneura comes* Say) with four ounces of active material in one hundred gallons of spray (56). Eight ounces of active per hundred gallons is reported effective for control of grape berry moth (*Paralobesia viteana* Clem.) (15). One report indicates thirty-two ounces active per acre was used to effect control of grape leaf folder (*Desmia funeralis* Hbn.).

GUTHION has been tested on several small fruits. Test results on strawberry show that eight ounces of active material per one hundred gallons of spray is effective against oblique-banded (*Archips rosaceana* Harr.) and strawberry (*Ancyliis comptana frageriae* W. and R.) leaf rollers, meadow spittlebug (*Philaenus leucophthalmus* L.), strawberry whitefly (*Trialeurodes packardi* Morrill), and two-spotted mite (*Tetranychus telarius* L.). On blackberry, twelve ounces of active material per acre was very effective against strawberry weevil (*Anthonomus signatus* Say.).

Lecanium scale (*Lecanium nigrofasciatum* Perganda) was effectively controlled with eight ounces of active material in one hundred gallons of spray on blueberry. This same rate was effective for control of two-spotted mite (*Tetranychus telarius* L.) and leaf roller (not identi.) on currants, and again this rate was effective for controlling aphids (not identi.) on raspberry. Cranberry fruit worm (*Acrobasis vaccinii* Riley) and Sparganothis fruitworm (*Sparganothis sulfureana* Clem.) were very effectively controlled with sixteen ounces of active material GUTHION per acre as a spray on cranberry.

On nut trees, control of codling moth (*Carpocapsa pomonella* L.) has been experienced with rates of five ounces of active material per hundred gallons on almonds and walnuts. Four ounces active per hundred gallons is also effective on European red mite (*Panonychus ulmi* Koch). Sixteen ounces of active per acre provided excellent control of soft scales (*Lecanium prunosum* Coq., *L. corni* Bouché, *L. cerasorum* Ckll.) on walnut.

A range of four to eight ounces active material per hundred gallons is also reported effective for navel orange worm (*Paramyelois venipars* Dyar), walnut aphid (*Chromaphis juglandicola* Klth.) (39), filbert leaf roller (*Archips rosana* L.), filbert aphid (*Myzocalis coryli* Goltze) and filbertworm (*Melissopus latiferreanus* Wlsm.) on these crops.

On pecans, a range of five to eight ounces active material per hundred gallons has been effective for control of black pecan aphid (*Melanocallis caryae-foliae* Davis), pecan nut casebearer (*Acrobasis caryae* Grote), and hickory shuckworm (*Laspeyresia caryana* Fitch.).

Results reported on tests on artichoke indicate forty-two ounces of active material per acre was highly effective for control of artichoke plume moth (*Platyptilia carduidactyla* Riley).

On various varieties of vegetable beans, bush beans, lima beans, kidney beans, and soybeans, two ounces of active GUTHION provide control of two-spotted mite (*Tetranychus telarius* L.) (54) and Pacific mite (*Tetranychus pacificus* McG.). Mexican bean beetles (*Epilachna varivestis* Mulsant) are effectively controlled with eight ounces of the active material per acre or per hundred gallons of spray. Twelve ounces of active material per acre effectively control potato leafhopper (*Empoasca fabae* Harr.).

On broccoli, eight ounces of active material per acre provided control of cabbage looper (*Trichoplusia ni* Hbn.) and imported cabbageworm (*Pieris rapae* L.). Eight ounces active per hundred gallons was highly effective in control of cabbage aphid (*Brevicoryne brassicae* L.) on Brussels sprouts and cabbage. Control of thrips (*Thrips tabaci* Lind., *Frankliniella fusca* Hinds, *F. tritici* Fitch, *F. exigua* Hood, *F. tenuicornis* Uzel) on cabbage was poor with twelve ounces of active per acre (61).

GUTHION has been extensively tested against insect pests of cabbage. At rates of eight to twelve ounces active per acre, it is effective against imported cabbageworm (*Pieris rapae* L.) (10, 26, 60), cross-striped cabbageworm (*Evergestis rimosalis* Guenee) (10), diamond-back moth (*Plutella maculipennis* Curt.) (26, 60) and the harlequin bug (*Murgantia histrionica* Hahn). At these rates, results against cabbage looper (*Trichoplusia ni* Hbn.) have ranged from very good to poor (10, 26, 36, 58, 60).

At twelve ounces active material per acre, reported control of striped (*Diabrotica vittata* F.) and spotted (*Diabrotica undecimpunctata howardi* Barb.) cucumber beetles (reflected in terms of yield) on cantaloup was very good.

On cauliflower, eight ounces active material per hundred gallons was somewhat inferior for control of cabbage looper (*Trichoplusia ni* Hbn.) and imported cabbageworm (*Pieris rapae* L.). A higher dosage rate is indicated.

Against six-spotted leafhopper (*Macrosteles fascifrons* Stål), potato leafhopper (*Empoasca fabae* Harr.), spittlebug (not identi.), aphid (not identi.), tarnished plant bug (*Lygus lineolaris* P. de B.), and flea beetle (not identi.) on celery, control with eight ounces of active substance per acre was only fair. Additional field testing is suggested at this rate under conditions of heavy insect populations.

With eight ounces of active material per acre, tests on collards indicated fair control of both large and small cabbage loopers (*Trichoplusia ni* Hbn.).

On cucumber, eight ounces active material per acre provided excellent control of pickleworm (*Diphanis nitidalis* Stoll), but unsatisfactory control of serpentine leaf miner (*Liriomyza pusilla* Meig.).

On eggplant, effective control of two-spotted mite (*Tetranychus telarius* L.) was obtained with twelve ounces of active material. This rate did not provide satisfactory control of fleabeetle (*Epitrix fuscata* Crotch.).

In tests against cabbage looper (*Trichoplusia ni* Hbn.) on lettuce, good control is reported with rates of from eight ounces to twenty-seven ounces of active material per acre.

For control of onion maggot (*Hylemya antiqua* Meig.) attacking onions, very good results are reported from treatments of eight ounces active material per acre as a granular, in-furrow application (30) and one ounce active per pound of seed applied as a seed treatment. Eight ounces of active per acre is also effective for control of onion thrips (*Thrips tabaci* Lind.) (48, 49).

On green peppers, eight ounces active material per acre was highly effective against cabbage fleabeetle (*Phyllotreta striolata* F.).

On potatoes, dosage rates as low as two ounces of active material per acre, indicate GUTHION to be very effective for control of Colorado potato beetle (*Leptinotarsa decimlineata* Say). At a rate of four and one-half ounces of active per acre poor control of foxglove aphid (*Myzus solani* Kltb.), buckthorn aphid (*Aphis abbreviata* Patch), green peach aphid (*Myzus persicae* Sulz.), and potato aphid (*Macrosiphum solanifolii* Ashm.) was obtained. Another report indicates GUTHION at a rate of eight ounces active to the acre to be effective for green peach aphid on potatoes (32). Additional testing is indicated against these insects. Varying results were obtained against potato fleabeetle (*Epitrix cucumeris* Harr.) at a rate of eight ounces of active per acre. Here too, additional testing is suggested. Very good results have been obtained against potato leafhopper (*Empoasca fabae* Harr.) at twelve ounces of active per acre, but again, results with eight ounces of active per acre varied.

Against tarnished plant bug (*Lygus lineolaris* P. de B.), eight ounces and sixteen ounces active per acre were not effective, nor were these rates effective against six-spotted leafhopper (*Macrosteles fascifrons* Stål).

On squash, GUTHION at the twelve ounce active per acre rate provided good control of a complex of striped cucumber beetle (*Diabrotica vittata* F.), spotted cucumber beetle (*D. undecimpunctata howardi* Barb.), squash vine borer (*Melittia curcurbitae* Harr.) and squash bug (*Anasa tristis* De G.) (reflected in terms of yield).

Applications at the rate of sixteen ounces active material per acre effectively reduced populations of a maggot complex (*Scaptomyza graminum* Fall., *Hyle-*

mya cilicrura Rond., *Muscina stabulans* Fall., *Muscina assimilis* Fall.) on spinach (24.). Four ounces, eight ounces and sixteen ounces active per acre provided effective control of spinach leafminer (*Pegomya hyoscyami* Panzer) in beets. Eight ounces active per acre was also effective in controlling pea leaf miner (*Liriomyza langei* Frick) in spinach. The twelve ounce rate of active per acre also significantly reduced populations of cabbage maggot (*Hylemya brassicae* Bouché) in radish.

The rate of three ounces active material per one hundred gallons provided highly effective control of whitefly nymphs and pupae (not identi.) on tomatoes. Four ounces active per hundred gallons was not particularly effective against *Drosophila*. Eight ounces active per acre provided highly effective control of tomato russet mite (*Vasates lycopersici* Massee).

Against insect pests of corn, six ounces of active material per acre as a spray provided effective control of corn earworm (*Heliothis zea* Bod.); twelve ounces of active material as a spray was more effective. For the first brood European cornborer (*Pyrausta nubilalis* Hbn.) eight ounces of active material per acre as a granular was approximately equal to DDT. Against second brood, eight ounces of active material per acre as a granular was equal to sixteen ounces of DDT, twenty-four ounces active substance per acre as a spray was again approximately equal to DDT. Eight ounces of active material per acre is highly effective for control of fall armyworm (*Laphygma frugiperda* S. and A.) attacking corn.

The toxicity of GUTHION to tobacco budworm (*Heliothis virescens* F.) has been determined in laboratory (22) and field tests. Eight ounces of active material per acre appears to be an effective rate for good control. For first brood tobacco hornworm (*Protoparce sexta* Joh.), five ounces active per acre is reported effective. Nine ounces active per acre is reported effective for second brood tobacco hornworm. The five ounces active per acre rate is also quite effective for tobacco fleabeetle (*Epitrix hirtipennis* Melsh.). Three ounces of active material per acre was effective for green peach aphid (*Myzus persicae* Sulz.) and results indicate the five ounces active rate is highly effective for control of this organism (8).

Control of meadow spittlebug (*Philaenus leucophthalmus* L.) and potato leafhopper (*Empoasca fabae* Harr.) was obtained with four ounces of active GUTHION per acre on alfalfa. A high degree of control of these pests was obtained with eight ounces of active per acre. The rate of five ounces of active per acre was effective against the spotted alfalfa aphid (*Therioaphis maculata* Buckton) (55). Results reported warrant further testing within the range of four to eight ounces of active material per acre.

European red mite (*Panonychus ulmi* Koch) was effectively controlled on hops with sixteen ounces of active GUTHION per acre. A lesser dosage rate is indicated.

Tests on vetch indicate eight ounces of active material per acre is effective against pea aphid (*Macrosiphum pisi* Harr.) and omnivorous leaf tier (*Cnephasia longana* Haw.). On clover, the rate of eight ounces of active material per acre provided control of meadow spittlebug (*Philaenus leucophthalmus* L.), but this rate was inadequate for control of lesser clover leaf weevil (*Hypera nigrirostris* F.).

Results of tests against red-necked peanut worm (*Stegasta bosquella* Chamb.) on peanuts indicate sixteen ounces of active material per acre was effective for control of this pest.

Armyworm (*Pseudaletia unipuncta* Haw.) was very effectively controlled on barley with four and eight ounces of active material per acre.

On pine trees, sixteen ounces of active material per hundred gallons was effective for the control of European pine shoot moth (*Rhyacionia buoliana* Schiff.). Twenty-four ounces of active material per acre was highly effective. Also on young pine, eight ounces of active material per acre was highly effective for control of Nantucket pine tip moth (*Rhyacionia frustrana* Comst.), by both aerial and ground mist spray applications (44).

On ornamental plants, three ounces of active material per hundred gallons provided excellent control of two-spotted mite (*Tetranychus telarius* L.) on dahlia. Eight ounces of active material per hundred gallons was equally effective for control of Japanese beetle (*Popillia japonica* Newm.) on rose and sassafras. Laboratory studies show GUTHION to be highly toxic to this pest (23). Iris borer (*Macronoctua onusta* Grote) was very effectively controlled with twelve ounces of active material per hundred gallons.

GUTHION has also been tested against houseflies and mosquitoes. A one-tenth per cent concentration (thirteen ounces of active per hundred gallons) was found to be effective for control of housefly (*Musca domestica* L.). Applications at twenty-five to fifty milligrams of active per square foot effectively reduced populations of housefly larvae in poultry droppings (29).

Applications of twenty-five milligrams per square foot and one to two ounces active material per acre have provided effective kill of fourth instar mosquito larvae (*Aedes nigromaculis* Lind. and *Culex tarsalis* Coq.). Against a midge, (*Tendipes plumosus* L.), a rate of two ounces provided effective control of this pest (28).

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Some Observations on Pest and Disease Control in English Orchards

by M. D. Austin, F. R. E. S.

Fruit growing in England has become such an integral part of the Agricultural/Horticultural branch as to be well termed "traditional", and of the fruits generally cultivated in England pome and stone fruits predominate in many areas. The following figures derived from the 1957 Orchard Fruit Census will serve to emphasise the importance of pome and stone fruit growing in England. Of the apple varieties grown, there is a total of some 26,000 acres of Cox's Orange Pippin, with the variety Worcester having a total acreage of some 13,000, whilst some 24,000 acres are given to the production of several other dessert varieties. The comparable Culinary apple acreage is approximately 30,000. Some 17,000 acres of pears, 25,000 of plums and 17,000 acres of cherries are also grown.

Of the very considerable acreage of pome and stone fruit, most is found in a comparatively few counties, and in fact the greater proportion is in the south eastern area of England, in the counties of Kent, Sussex, Essex, Suffolk

and Cambridgeshire, whilst an extensive acreage of pome and stone fruit is also grown in the West Midlands.

Nevertheless, over the last twenty to thirty years, fruit growing, particularly that of pome and stone fruit has become a specialist proposition, thus we would now say that fruit growing has for some time in this country been a considerable business enterprise. A notable feature of the English commercial fruit grower's outlook is that he is both progressive and ever willing to investigate and use modern techniques as they arise, and further shows a great aptitude for adopting many advances in many fields in this very involved business. For instance, and this cannot be too highly emphasised, the alert fruit grower of today will be vitally interested not only in developments in connection with fruit in this country but also in relevant matters as they are revealed in commercial and scientific World literature. Thus, in general, in contradistinction to the conservative agricultural outlook of some farmers, the majority of commercial orchardists will be very alive to modern developments and trends and will demand from the technical service within their reach a high standard of day-to-day service.

That this is necessary and indeed welcome needs little emphasis since with routine pest and disease control in a typical orchard of dessert apple varieties such as Cox/Worcester, at least 8 separate sprayings will be required; these sprayings will at times include both insecticide and fungicide. Pre-blossom sprayings at bud burst and green cluster for the control of aphids and caterpillar and also Apple Scab, are usually required. At pink bud, the fungicidal spray will frequently be concerned with Scab and Mildew control whilst in addition to a somewhat similar spraying at Petal Fall the control of Apple Sawfly is also then necessary.

The control of Fruit Tree Red Spider Mite becomes necessary at the early fruitlet stage, but here again the acaricide will probably be added to the Scab/Mildew spray. Later on, at least two sprayings will be applied for Codling Moth (*Carpocapsa pomonella*) and Late Tortrix (*Adoxophyes orana*) control, with possibly further sprayings against Fruit Tree Red Spider Mite (*Metatetranychus ulmi*).

Of the pests dominant in the orchards today, Fruit Tree Red Spider Mite and Codling Moth are perhaps most important. Dominant among the comparably few fungus diseases of apple, Mildew (*Podosphaera leucotricha*) is now causing the most concern to growers, for its spread in orchards is so rapid and extensive that the productivity of the trees is sharply reduced.

However, today, with an ever increasing need for extending the effective commercial storage life of dessert apple varieties such as Cox and Laxton Superb, the control of storage rots caused by *Gloeosporium* spp. also becomes urgent. Thus July and August and even September sprayings with suitable fungicides are now a part of the orchard routine on many farms.

In this connection, the amazing and sometimes very spectacular advances in spray application through modern machinery have progressed at such a pace that the spray machinery manufacturers are hard pressed to develop the machines to incorporate all of the necessary changes. The partial change-over, probably involving up to a third of the growers, from high volume spraying techniques to that of medium and low volume spraying techniques, has taken place within the span of a relatively few years. Thus it is now

generally considered that sprays used at the rate of 100 gallons or more per acre is high volume spraying, with the medium volume spraying rate ranging from 50 to 100 gallons per acre, whereas anything below 50 gallons is referred to as low volume spraying. This in turn has presented a unique challenge to the technical staffs of manufacturers of spray materials and spray formulations, for not only have the sprays to be capable of being used in the newer types of machinery, but an ever higher standard of spray performance is required in the field. This wide based approach of fruit farmers to the technology of pest and disease control has side-by-side produced an awareness of the need for complete cooperation with the spray manufacturers. The growers on their part fully realise that to be of material assistance to them, the spray formulators must have in addition to the unique facilities for laboratory and field scale experiments, some wider field experience in the employment of their



Fig 1 Concentrate spraying of a standard tree orchard (Photo by kind courtesy of Drake and Fletcher, Maidstone, Kent)

own products. Thus we happily find that many commercial orchardists welcome the opportunity of allowing spray manufacturers to use even considerable acreages of their trees for the purpose of the field testing of certain chemical products.

Without this cooperation, both grower and manufacturer would be the poorer because one of the immediate results of such cooperation is that promising materials are the more quickly sorted out in the field, and, if suitable, are then available for use in the grower's spraying routine. We here use the word 'routine' in its widest sense, because if there is any one operation



Fig. 21. *Centrifugal sucking of a dormant orchard (Photo kindly courtesy of Drake and Fletcher, Maidstone, Kent)*

on an English fruit farm which can clearly be called routine it is that of spraying to give trees and fruit effective protection against a number of serious pests and diseases. Indeed on many farms, the successful control of both Apple Scab and Mildew entirely depends on a continuous productive fungicidal coverage of both foliage and fruit over a relatively long period. For this purpose sprays are applied at intervals of from 10 to 14 days throughout a considerable part of the season.

Although we are not here concerned with the general economics of fruit farming, it may be confidently stated that a very high proportion of the

expenditure of an up-to-date fruit farm these days is that incurred in connection with pest and disease control. In short, as an item of expenditure, it probably ranks with such practices as manuring, pruning and the like. We have indicated that the British fruit grower's general outlook is always progressive and it is inevitable, therefore, that not only would he be concerned with pest and disease control, but he should give as much attention to the general health of the orchard trees themselves. It must, therefore, be pointed out that far from expecting spray materials to work modern miracles in the orchard on their own, the fruit grower well knows that unless soil fertility and tree health are of a high standard, his maximum production of high quality fruit will fall well below potential. For instance, most growers will well appreciate the benefits to be derived from the grassing down of many orchards. They also appreciate that this sward should be capable of proper management, particularly bearing in mind other factors, such as soil structure and rainfall.

In short, when we are dealing with English fruit growers we are concerned with individuals who generally well know their job, and only look outside for assistance when they are concerned with breaking into new fields of thought. Thus for any spray manufacturing company to do justice to itself it must be well served in the field, as well as in the laboratory, by people who are equipped with the latest information as well as having considerable background experience. Therefore, nowadays, for representatives in the field to be successful, they must in addition have the backing of efficient service and knowledge which can only be fully derived from an organisation with considerable experience.

Messrs. Baywood started field trials with various chemicals in a number of English orchards in 1955. In view of the excellent practical experience that had been gained with METASYSTOX® in the control of certain agricultural pests, particularly aphids on sugar beet and thus inferentially of sugar beet yellows, the prime objective was naturally to test the suitability of this very substance for controlling pests in English orchards.

Of the various pests attacking top fruit in this country, the Fruit Tree Red Spider Mite has for long since been notorious. Although for some years there have been a range of materials, which, if used at the correct times and applied on several occasions, held this pest well within reasonable limits, there had long been a need for a spray material having an immediate "knock down" effect and also, which is more important, a fairly lengthy residual action. For these reasons METASYSTOX, which has both of these desirable qualities with the residual effect being linked up with its very valuable systemic action, was well chosen.

For the purpose of field experiments, orchards in Cambridgeshire, Suffolk and Kent were made available to us, and the data refers briefly to some of these experiments. It will be understood that generally a considerable acreage of trees was involved, but for the sake of brevity the account has been limited so as to allow only the inclusion of minimal relevant notes on the experiments. In 1955 field work was carried out on Fruit Tree Red Spider Mite, Plum Sawfly, Apple Sawfly, Apple Aphids and Hop Damson Aphids, and the findings are discussed here.

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1. Fruit Tree Red Spider Mite (*Metatetranychus ulmi*)

a) on plums. For this experiment in Cambridgeshire, a block of Giant Prune and Severn Cross, heavily infested with winter eggs, was available. METASYSTOX was applied at 12 oz. per 100 gals. with a K.E.F. automatic spraying machine at a rate of approximately 300 gals per acre on June 6th, when winter egg hatch was from 50 to 65 per cent. An adequate number of trees were left unsprayed to serve as controls. Leaf population sampling before spraying gave the following figures per 100 leaves:

Table 1: 6th June

	Mites	Summer eggs
Giant Prune	1736	121
Severn Cross	2365	154

Further comparable samplings during the season gave the following figures:

Table 2:

Date		Mites	Summer Eggs
17th June*			
Sprayed	Giant Prune	35	15
	Severn Cross	29	21
Unsprayed	Giant Prune	1509	1622
	Severn Cross	1921	2041
4th July			
Sprayed	Giant Prune	19	27
	Severn Cross	26	69
Unsprayed	Giant Prune	3717	2640
	Severn Cross	5169	4106
18th July			
Sprayed	Giant Prune	39	52
	Severn Cross	64	69
Unsprayed	Giant Prune	636	1701
	Severn Cross	914	2075
19th August			
Sprayed	Giant Prune	126	101
	Severn Cross	112	103
Unsprayed	Giant Prune	1306	2004
	Severn Cross	1419	2864

* on this date June 17th, winter egg hatch was complete.

It can be seen from these figures that the trees sprayed in early June were even in mid-August relatively free from mite infestation; on this date the foliage was still completely green, whereas the control trees were heavily infested and completely bronzed.

- b) on apples. Field experiments were carried out at several centres in certain counties, including Suffolk and Kent. The following account refers to one of the Suffolk centres. There an orchard of Worcester Pearmain and Cox's Orange Pippin with a relatively high winter egg population, was sprayed with METASYSTOX at 12 oz per 100 gals on 1st June, at a rate of approximately 250 gals per acre, when the winter egg hatch was approximately 65 per cent. Mite population samplings on 1st June and on later dates during the season gave the following figures per 100 leaves:

Table 3:

Date	per 100 leaves	
	Mites	Summer Eggs
1st June	905	16
8th June	62	21
15th June	10	18
20th July	6	14
8th August	45	62

These figures show that one spraying with METASYSTOX in June resulted in relative freedom from mites well into August. This freedom from mites was also emphasised by the absence of foliage bronzing which was very heavy on some trees in the same orchard not sprayed with METASYSTOX.

In a year characterised by heavy and continuous mite infestation, the control achieved by one spraying with METASYSTOX is noteworthy.

The heavy infestations of the red spider mite during the Summer and Autumn of 1955, was followed by the oviposition of large numbers of Winter eggs. Thus most orchards had a spider problem, and in 1956 the early Summer infestations were relatively heavy.

For an experiment on red spider mite on plums, a Purple Pershore orchard was selected in Cambridgeshire. METASYSTOX was applied at a rate of 12 oz per 100 gallons, using 300 gallons of spray wash per acre, on May 15th, when there was a 45 per cent winter egg hatch. A population count taken just before spraying showed 285 mites in various stages per 100 leaves. The following table gives the comparable population figures for samples taken subsequently:

Table 4:

Date	Mites	Summer Eggs
Pre-spraying	285	0
26th May	12	3
3rd June	15	0
27th June	32	11
15th July	75	29

On July 15th the comparable population on trees which did not receive METASYSTOX was 462 mites and 2019 eggs per 100 leaves, thus showing that one METASYSTOX treatment brought about a considerable reduction in the gross mite population.

A similar trial in Suffolk was undertaken in an apple orchard of the varieties Cox and Miller's Seedling. The spray was applied on the 31st May, when the winter egg hatch was approximately 75 per cent. The rate of application was 12 oz per 100 gallons; 200 gallons of spray were applied per acre. 204 mites and 5 summer eggs were recorded from a total of 100 leaves before spraying. Further population figures are given in the table below:

Table 5:

Date	Mite population per 100 leaves	
	Mites	Summer Eggs
10th June	7	12
21st June	15	6
3rd July	9	12
10th July	45	33
22nd July	59	75

A population count taken on trees which were not sprayed with METASYSTOX, yielded 871 mites and 192 summer eggs per 100 leaves on July 22nd.

In recent years the bryobia mite has caused quite serious damage in certain orchards, and it is therefore interesting to note that a serious infestation on pears in a Kentish orchard was completely controlled by one pre-blossom application of METASYSTOX at the standard rate.

This confirms the general experience that METASYSTOX is not only effective against Red Spider Mite, but, through its contact and systemic action, also produces a quick kill of all active stages of other spider mites such as *Bryobia* and Glasshouse Red Spider Mite (*Tetranychus althaeae*).

2. Woolly Aphis (*Eriosoma lanigerum*)

In a large number of orchards where routine applications of METASYSTOX were made to control Red Spider and other pests, observations were made of its effect on Woolly Aphis (*Eriosoma lanigerum*). This insect did not develop as a serious pest during the Summer of 1956, but enough information was collected to show that METASYSTOX has a considerable controlling effect.

In a trial control of Woolly Aphis, on 3 acres of Cox, we found that using METASYSTOX at the rate of 12 oz per 100 gallons of water and sprayed at relatively high volumes (200 gals per acre), a good control of Woolly Aphis was effected by one pre-blossom spraying with an even more satisfactory result by the use of immediate post-blossom application. However, this pest was virtually eliminated on the trees in the orchard which received both the pre- and post-blossom applications. This, of course, is in general line with Woolly Aphis control, for it is seldom that it can be eliminated with but one spraying. It is interesting to note that an Autumnal (October) spraying with METASYSTOX at 12 oz per 100 gals was applied to a block of Cox trees in the same orchard as that above, and this treatment so reduced the Woolly Aphis that it is likely that with the coming of Spring, not many, if any aphids, will be present on these particular trees. The check (unsprayed) trees were still heavily infested in October, 1958.

Table 6:

Woolly Aphis Control — 1958

(based on examination early July: figures per 10 "recorded" trees)

METASYSTOX	pre-blossom	17 active colonies
12 fl. oz 100 gals	(1st May)	
12 fl. oz 100 gals	post-blossom	7 active colonies
	(3rd June)	
12 fl. oz 100 gals	pre- and post- blossom	2 active colonies
	(1st May/3rd June)	
Check (unsprayed)		264 active colonies

3. Plum Sawfly (*Hoplocampa flava*)

The 1955 season was characterised by only light infestations of the Plum Sawfly. However, it was found possible to carry out a small scale experiment in an orchard in Cambridgeshire on the variety Wyedale. METASYSTOX was applied at 12 oz per 100 gals on 19th May, which was a little later than cot-split stage. The use of METASYSTOX resulted in a degree of control at least as good as for BHC which was used as a comparative spray. Further, our observations support the conclusion that METASYSTOX had a slightly greater penetrative effect than BHC, and it can, therefore, be expected that, commercially, good results will be achieved even in seasons when infestations are heavier.

There was also red spider infestation in this orchard, which was reduced to the same extent as in the red spider experiments mentioned above.

The results of this experiment are confirmed by the experience gained in a number of large scale trials on the Continent where METASYSTOX proved to be highly effective against Plum Sawfly.

Further work on the control of Plum Sawfly in 1956 confirmed our findings of the previous season, when it was shown that one application of METASYSTOX shortly after the cot-split stage, resulted in an almost complete control of this pest.

The following figures derived from a trial in Cambridgeshire on the variety Purple Pershore, support this statement: — In the METASYSTOX plots, there was one infested fruitlet out of 1 000, whilst 32 fruitlets per 1 000 were found in the unsprayed controls.

4. Apple Sawfly (*Hoplocampa testudinea*)

Owing to the erratic behaviour of Apple Sawfly in 1955, it was not possible to carry out completely satisfactory trials. However, sufficient information was derived from the field experiments and during commercial application to show that one application of METASYSTOX at 12 oz per 100 gals carried out 8 days after petal fall, gave a remarkable reduction in infestation.

It is interesting to record that in a season such as was experienced in 1955, when the secondary invasion of fruit was of considerable importance, an application of METASYSTOX when primary infestation had already occurred, completely prevented secondary infestation of fruitlets. In addition, it was observed that this late application killed the sawfly maggots in the fruitlets within a period of 48 hours.

5. Apple Aphids

In the Spring of 1955, several commercial trials were carried out in Kent in order to ascertain the effect of METASYSTOX on mixed aphid populations, consisting of Green Apple Aphis (*Doralis pomi*), Oat-Apple Aphis (*Rhopalosiphum insertum*) and Rosy Leaf Curling Aphis (*Sappaphis devector*). METASYSTOX was applied on 31st May to Lord Derby and Bromley Seedling standard trees at a rate of 12 oz per 100 gallons, using 300 gals wash per acre. Counts made before spraying, showed that the average infestation was 65 aphids of all stages and species per leaf. At this time many of the Rosy Leaf Curling Aphids were completely sheltered within the curled portions of the leaves.

An examination made on 1st June failed to reveal any active aphids, and this complete control was still manifest on the 9th and 17th June. On neither of these two late dates were any live aphids to be found.

This result was also achieved in quite a number of other orchards in Kent.

6. Hop-Damson Aphis (*Phorodon humuli*)

The effect of METASYSTOX on Hop-Damson Aphis was examined in a number of trials in East Kent. The figures given below refer to one of these experiments on the variety Eastwell Goldings. High volume spraying was carried out on 23rd June at 12 oz per 100 gals. At this time the aphid population was about 30 aphids per leaf, including a small proportion of winged forms. Counts carried out subsequent to spraying produced the following results:

Table 7:

	Aphis per leaf	
	on lower part of plant	on upper part of plant
7th July	1.4	0.3
14th July	1.1	0.8

During this period the aphid population on the unsprayed plot had increased to over 60 aphids per leaf in the upper parts of the hop plants. These figures underline the residual effect of METASYSTOX, for in this instance the spray was effective for 22 days. The results of this trial were confirmed by commercial experience on many farms where two applications of METASYSTOX kept the hops free from aphids throughout the season.

A more detailed account of the above field experiments was published in the "Commercial Grower" of February 10th, 1956.

Further work on similar lines was carried out in the following season, 1956, when the general experience with METASYSTOX for Fruit Tree Red Spider Mite was confirmed.

In addition our earlier findings in connection with the control of Plum Sawfly with METASYSTOX were also confirmed.

7. Apple Scab (*Venturia inaequalis*)

A new formulation of TMTDS known under the name of POMARSOL® FORTE was employed in a large scale field experiment on the varieties Cox's and Miller's Seedling in Suffolk. POMARSOL FORTE contains 80 per cent TMTDS, and because of its high plant compatibility, can be safely used even on sulphur-shy varieties. It was applied as a routine spray, with 3 pre-blossom and 5 post-blossom sprayings at a rate of 1½ lbs per 100 gals. Scab infections were recorded on leaf and fruit at various intervals during the season. The results are given in the following table:

Table 8:

	Scab infections per 1000 sample leaves		
	POMARSOL	POMARSOL	unsprayed
Mid-June	0	0	63
Mid-July	0	0	245
	Fruitlet infections per 1000		
Mid-June	0	0	1
Mid-July	1	3	48

These figures need no further emphasis, as they show the high efficiency of POMARSOL FORTE in the control of Apple Scab at relatively low rates of use. Not only did POMARSOL FORTE effectively control Scab (*Venturia inaequalis*), but it was very obvious in the field that it was responsible for producing a very fine fruit finish. This confirms the observations made in 1956 in Kentish orchards where POMARSOL FORTE was used on a commercial scale with great success especially on sulphur-sensitive varieties such as Newton Wonder.

Further details of these experiments were given in the "Commercial Grower" of 22nd February, 1957.

8. Gloeosporium Rot

Among the number of field experiments also carried out in 1957 an interesting one on the orchard control of *Gloeosporium* was undertaken in Essex. We must here briefly refer to the fact that with the considerable extension in the acreage of dessert apples such as Cox's and Laxton Superb, the need for fruit with a long storage life has become more generally apparent. With a larger bushelage of apples to deal with, and as there is only a limited market to absorb the fruits, the tendency has been, and still is, for certain varieties of apples to be cold-stored for longer and longer periods. Unfortunately there are certain limitations, and with certain reservations the longer some apple varieties are stored the greater is the risk of their breaking down with storage rots, notably *Gloeosporium* spp. Thus English fruit growers are very alive to the necessity of protecting stored apples from the attacks of *Gloeosporium*, and therefore the need for employing measures to control its incidence has much support among growers. The brief results of our 1957 experiments in this regard, where July and August applications of POMARSOL FORTE were applied to blocks of the variety Cox's, now follow.

For the purpose of these experiments a well established orchard of Cox's was placed at our disposal. The orchard, of several acres, was divided into four comparable blocks, one of which was sprayed with a normal concentration of POMARSOL FORTE on the 24th July, another area being sprayed on the 24th July and the 22nd August, whilst a third area was sprayed on the 22nd August only; block four received no POMARSOL FORTE at all.

The fruit from this orchard was harvested in October and was placed in gas storage, and thus the fruits were not examined until the store was opened

in mid-December, 1957. The fruits were examined as they passed over the grader; culls were eliminated and the fruit was packed for normal market. In the case of the fruit from Block 2 and also the Control Block, these were retained in store for later examination. However, as a result of the examination on the 16th and 17th December, the following figures with reference to the incidence of *Gloeosporium* rots were obtained:

Sprayed in	July only	7 %
Sprayed in	July/August	6 %
Sprayed in	August only	7.5 %
	Control (unsprayed)	10 %

The boxes of fruit retained for further examination were taken out of store on the 22nd January, 1958, when the percentage of *Gloeosporium* was as follows:

Sprayed in	July only	17 %
Sprayed in	July/August	10 %
Sprayed in	August only	14 %
	Control (unsprayed)	24 %

It is clear from the above figures that whereas the single treatment of POMARSOL FORTE in July and August materially reduced the percentage of storage rots, the combined July/August applications reduced the amount of rotting more substantially.

It is of interest here to note that in one of our 1958 field experiments where a full Baywood Programme was applied to part of an orchard of Cox's in Suffolk, the routine use of POMARSOL FORTE applied on the 12th June, 1st July, 9th July and 11th August resulted in inhibition of *Gloeosporium* rots in store of an order equal to that for similar applications of Captan. In fact when appropriate samples were examined on the 20th of February, 1959, the percentage of *Gloeosporium* from the POMARSOL FORTE plots was 7 %, and from the Captan plots 7.5 %, whilst that on fruit from trees which had received no sprayings at all was in the neighbourhood of 27 %.

9. New products

New products or formulations are subjected to biological tests both in the laboratory and in the field before being used in commercial trials. For this purpose, the Baywood Experimental Farm at Hextable in Kent is used, and here new test series are carried out each year.

Thus in 1958, the new products GUSATHION® (4619) and 4536, a new METASYSTOX formulation still in the experimental stage of usage, were subjected to exacting and controlled tests; Fruit Tree Red Spider Mite and Summer Tortrix (*Adoxophyes orana* F. R.) were used as test organisms. The biological observations were made by Mr. A. Woods and Miss K. Powell. The tests were arranged as follows:

Design 4 × 6 randomised blocks, each plot consisting of nine trees (plant 20 × 20 feet).

Table 9: Spider Mite Trials

	June 10th 1 week	June 17th 2 weeks	June 24th 3 weeks	July 2nd 4 weeks	July 8th 5 weeks	July 15th 6 weeks	Sept. 2nd 13 weeks
Mites							
METASYSTOX	2	2.2	1.5	1.25	0.7	4.7	692
4536	3.25	3.5	3	0.25	1.5	3.7	1037
GUSATHION	1.5	8.2	5	8.2	0.25	4.5	94
Control	91 31.75	93.4 57 } 75.2	103 63.7 } 83.3	164.7 74.7 } 119.7	619 127 } 373	400 251 } 325	4090 4675 } 4382
5 % least sig. diff. between Control and any other mean	42.2	32.8	30.6	36.4	119.9	101.3	1713
Eggs							
METASYSTOX	120	27	0.25	0.5	1.5	14	229
4536	118	33	0.7	2.0	0.5	13	197
GUSATHION	210	18	2.0	1.0	0	3	62
Control	165 183 } 171	394 73 } 233	497 124 } 310	972 525 } 747.0	1444 1166 } 1305.0	2226 2018 } 2122	897 1020 } 958
5 % least sig. diff. between Control and any other mean		153	175	264	519	523	541

Varieties	Cox's Orange Pippin and Worcester Pearmain. Blocks I, III and IV entirely of Cox; Block II six Worcesters and three Cox's per plot, the central tree being a Worcester.
Treatment	Spraying carried out using a 15 gallon capacity Dorman sprayer with hand lance. Rate approx. 180 gallons/acre.

A. Red Spider Mite Trial

Materials:	1. GUSATHION (4619)	20 fl. oz./100 gals. = 0.125 %
	2. 4536	8 fl. oz./100 gals. = 0.05 %
	3. METASYSTOX	12 fl. oz./100 gals. = 0.075 %
	4. and 5. Checks	
Spraying dates:	for GUSATHION	June 3rd, June 30th and July 24th
	for 4536	June 3rd
	for METASYSTOX	June 3rd

Sampling took place at approximately weekly intervals (7—8 days) from the date of the first spray up to six weeks, and a final end-of-season sample was taken thirteen weeks later. In all cases samples were taken from the single central tree of the plot, 25 leaves being picked randomly all round the tree at about 5' from the ground. A summary of these results is given in Table 9. The actual numbers are obtained by taking the total number of mites and eggs from the four blocks and calculating the mean. In addition, the least significant difference between means is given.

B. Summer Tortrix Trial

Materials:	GUSATHION	1 pt. /100 gals. = 0.125 %
	Comparison product*	3 pts./100 gals. = 0.375 %
Spraying dates:	June 30th	
	July 24th	

Sampling took place after the fruits were picked, and the total number of damaged fruits in each plot counted; the Worcesters were excluded from this count (it was not realised until several plots had been checked that there was sufficient damage to record) and, therefore, in Block II a total was obtained from 3 trees per plot, instead of 9 as in the others. This was, however, compensated for in the analysis of results by multiplying by three. Thus the figures given below represent the total number of Tortrix-attacked fruits per plot.

Table 10:

	Block I	II	III	IV	Total	Mean/Plot
GUSATHION	1	0	0	1	2	0.5
Comparison product*	6	0	15	3	24	6.0
Control	38	51	56	93	238	59.5
Control	97	69	41	64	271	67.7

5 % least significant difference 18.68.

* Dichlorodiphenyl trichloroethane, 26/27 % emulsion.

GUSATHION gave the best control of Summer Tortrix. In fact the treatment with the comparison product gave considerably better results than were recorded for the unsprayed check.

In addition, the fruit from the GUSATHION plots was noticeably better in appearance than that from the other treatments and although the plots were arranged randomly, thus compensating for variability in tree size, the yields appear to be consistently higher (Table 11).

Table 11:

	I	II	III	IV
GUSATHION	625	241	619	478
Comparison product	583	81	524	377
Check	336	190	468	392
Check	587	104	349	464

The above table shows the total number of fruits (Cox's) from each plot, i.e. those from 9 trees in blocks I, III and IV and 3 trees in block II.

Discussion

It must be appreciated that the field experiments and trials discussed in this paper are but a few of those undertaken with various Baywood products in English orchards over a period of some four years. Similarly it should be understood that during this period such was the confidence of an ever increasing number of growers in Baywood products that some of these materials, particularly METASYSTOX and POMARSOL FORTE, were being used in many orchards as a matter of routine. This is especially true of METASYSTOX, because this material was found to meet a really pressing need in connection with the orchard control of the Fruit Tree Red Spider Mite. Its subsequent use for the control of fruit tree aphids and in some cases Apple and Plum Sawfly was a natural and logical corollary.

Whilst this account mainly concerns work by the present writer, it was broadly based on the experience in this country of Dr. W. Linke and, therefore, owes much to him from its inception and onwards. It follows also that the field work would not have been possible except for the wholehearted cooperation of growers too numerous here to mention.

References:

- Report on METASYSTOX by M. D. Austin and W. Linke, "Commercial Grower" February 10th 1956.
- Pest Control Trials by M. D. Austin and W. Linke, "Commercial Grower" February 22nd 1957.
- Unpublished reports to Baywood Chem. Ltd., London, dated 22nd January 1958, 20th October 1958, and 2nd December 1958.

GUSATHION®* for controlling scale insects on evergreen ornamentals

by Rudolf Roesler and Heinz Schneider

Every gardener is only too well aware of the difficulties associated with the control of scale insects on evergreens. Apart from the old method of washing plants with nicotine, spirits and soft soap, there has hitherto not been a single product capable of effectively checking the very troublesome scale infestations that occur on many evergreen ornamental woody plants. The systemic insecticides, otherwise so very effective against sucking insects, fail here because growth is already completed on by far the greatest part of the foliage. In our search for suitable products, we came across several phosphorus compounds of Farbenfabriken Bayer Aktiengesellschaft, Leverkusen; according to the manufacturers, these compounds had already given good results in the control of scale insects on cotton and citrus crops.

The first test against *Coccus hesperidum* on laurel trees were carried out in autumn, 1957 in several nurseries; use was made of the products 4619 and 8300, applied at high and low dosages**. Only a few trees were severely infested so that only one concentration could be used in each test series. 200 to 300 insects were counted per product in the evaluation. Tables 1 and 2 give the results for the higher concentrations.

Table 1: Trial control of *Coccus hesperidum* on *Laurus* in a nursery at Neustadt a. d. Weinstrasse.
Spraying on Aug. 22, 1957; Evaluation on Sept. 20, 1957.

Product	Conc. in %	Mortality in %		Efficacy in %	
		old insects	young insects	old insects	young insects
GUSATHION (4619)	0.2	100	100	100	100
8300	0.5	100	100	100	100
E 605® forte	0.05				
+ methylated spirits	1.0	34.1	55.4	13.2	53.3
untreated	—	24.1	4.5	—	—

* GUSATHION = 0,0-dimethyl dithiophosphoric ester of 4-keto-3-methyl-1,2,3-benzotriazine.

The ethyl compound marketed in Germany under the trade name of GUSATHION-A is 0,0-diethyl-S-(4-oxy-1,2,3-benzotriazinyl-3-methyl) dithiophosphate.

** At first, E 605 forte 0.035 % and 0.05 %, with a 1 % addition of methylated spirits, was used as a comparison product.

Table 2: Trial control of *Coccus hesperidum* on *Laurus* in the municipal nurseries at Landau.

Spraying on Sept. 29, 1957; Evaluation on Dec. 18, 1957.

Product	Conc. in %	Mortality in %		Efficacy in %	
		old insects	young insects	old insects	young insects
GUSATHION	0.2	100	100	100	100
8300	0.5	95.0	100	94.8	100
untreated	—	4.0	13.0	—	—

All the preparations, which gave in almost every case a 100 % kill of both old insects and young scales, proved to be far superior to the comparison product (E 605 forte + methylated spirits).

A further spray treatment of laurel trees severely colonized by *Coccus hesperidum*, carried out on Oct. 17, 1957 at Mussbach a. d. Weinstrasse, using GUSATHION (4619) 0.2 %, confirmed the results of the two test series described above. The evaluation on December 18, 1957 also showed a 100 % mortality.

Differences in the efficacy of the various products were revealed in the series of tests in which low concentrations were used; the results are given below in Table 3.

Table 3: Trial control of *Coccus hesperidum* on *Laurus* in the municipal nurseries at Neustadt a. d. Weinstrasse.

Spraying on Aug. 22, 1957, Evaluation on Sept. 20, 1957.

Product	Conc. in %	Mortality in %		Efficacy in %	
		old insects	young insects	old insects	young insects
GUSATHION (4619)	0.1	100	100	100	100
8300	0.3	93.4	88.0	90.8	84.8
E 605 forte	0.035				
+ methylated spirits	1.0	40.5	53.1	17.4	39.1
untreated	—	28.0	21.3	—	—

GUSATHION (4619) gave a 100 % kill of old and young scale insects also at the lower concentration of 0.1 %, whereas the results recorded for the test product 8300 were not quite so high. Once again, a large number of young scale insects survived the application of E 605 forte, just as in the parallel test (Table 1). The juveniles produced by old insects that survive the treatment, remain unharmed as soon as the relatively short residual effect of E 605

forte has faded. The fact that hardly any live young insects were found in the tests with the other products, despite survival of old individuals, provides evidence of the long residual effect of these spray deposits.

In 1958, we had another opportunity of carrying out trial controls of *Coccus hesperidum*; in these tests, use was made only of GUSATHION (4619). The results are given in Tables 4 and 5.

Table 4: Trial control of *Coccus hesperidum* on *Laurus* in the municipal nurseries at Neustadt a. d. Weinstrasse.

Spraying on Sept. 11, 1958; Evaluation on Nov. 3, 1958.

Product	Conc. in %	Mortality in %		Efficacy in %	
		old insects	young insects	old insects	young insects
GUSATHION (4619)	0.2	98.0	99.2	97.6	99.4
GUSATHION (4619)	0.1	98.0	99.4	97.6	99.4
untreated	—	15.0	1.2	—	—

Table 5: Trial control of *Coccus hesperidum* on *Laurus* at Schifferstadt i. d. Pfalz.

Spraying on Sept. 30, 1958; Evaluation on Oct. 20, 1958.

Products	Conc. in %	Mortality in %		Efficacy in %	
		old insects	young insects	old insects	young insects
GUSATHION (4619)	0.2	98.2	100	98.0	100
GUSATHION (4619)	0.1	89.4	98.4	88.5	98.2
untreated	—	7.9	10.0	—	—

The good effect of GUSATHION was confirmed also in these tests. The results obtained for the two concentrations did not vary to any really appreciable extent. The very small number of young scale insects that survived the treatment, once again demonstrates that the product has a long residual effect; Unterstenhöfer drew attention to this in his paper on GUSATHION (Höfchen-Briefe 1958, No. 3, P. 81—90).

In 1958, a mass occurrence of the hemispherical scale *Saissetia hemisphaerica* on the fern species *Nephrolepis rooseveltii* was observed in a Neustadt nursery. The owner carried out several controls but did not succeed in checking the infestation. A trial spray application of GUSATHION (4619) 0.1 % was then carried out; at the time of this treatment, nearly all the eggs concealed under

the old dead females had hatched. Therefore, it was only possible in this test to establish the effect of the product on larvae and young females which had not yet laid any eggs. As the results in Table 6 show, GUSATHION gave a 100 % kill of these stages.

Table 6: Trial control of *Saissetia hemisphaerica* on *Nephrolepis rooseveltii* in a Neustadt nursery.

Spraying on Oct. 13, 1958; Evaluation on Nov. 18, 1958.

	Conc. in %	Mortality in %		Efficacy in %	
		adults	larvae	adults	larvae
GUSATHION (4619)	0.1	100	100	100	100
untreated	—	2.3	1.9	—	—

An opportunity to carry out tests with the object of establishing the ovicidal effect of GUSATHION (4619) on scale eggs still concealed under the protective scale of the mother insect, was provided on February 12, 1959 when large numbers of dead females with abundant egg deposits were observed on the untreated ferns. Following the treatment with GUSATHION (4619) 1 %, a number of the pinnae, colonized by scales, were cut out of the fonds, placed in Petri dishes and surrounded by a vaseline ring to trap the emerging larvae. The test revealed that the eggs had not been killed. The larvae, however, are killed by the spray deposit when they emerge while the deposit is still insecticidally effective.

On October 17, 1957, spraying tests were carried out at Deidesheim a. d. Weinstrasse with the products GUSATHION (4619) and 8300 on oleanders severely infested by *Aspidiotus hederae*. The male oleander scales were not counted in the evaluation of the test. Some time after the test, it was noticed that the bodies of many insects, especially females, became swollen and deformed, so that the scale was raised partly uncovering the insect. As such

Table 7: Trial control of *Aspidiotus hederae* on oleander at Deidesheim.

Spraying on Oct. 17, 1957; Evaluation on Dec. 18, 1957.

Product	Conc. in %	Mortality in %			Efficacy in %		
		fe- males	young insects	egg larvae	fe- males	young insects	egg larvae
GUSATHION (4619)	0.2	96.6	99.8	98.1	96.2	99.7	97.9
8300	0.5	81.2	100	98.9	79.2	100	98.8
untreated	—	9.6	2.7	6.4	—	—	—

Table 8: Trial control of *Aspidiotus hederae* on oleander at Königsbach i. d. Pfalz.

Spraying on Aug. 4, 1958; Evaluation on Sept. 26, 1958.

Product	Conc. in %	Mortality in %		Efficacy in %	
		females	young insects	females	young insects
GUSATHION (4619)	0.2	92.3	99.3	90.4	97.7
8300	0.5	100	89.7	100	66.6
untreated	—	20.3	69.0	—	—

deformed scale insects do not recover, they were counted as dead in the evaluation. The results of this test and a similar one carried out later are given in Tables 7 and 8.

The test conducted on October 17, 1957 (Table 7) was the only one in which slight injuries were inflicted on the foliage by the spray. The injuries took the form of dark, dry spots on the leaves, which were probably caused because spraying was carried out in the mid-day sun; this supposition is supported by the fact that the degree of damage was the same for both preparations.

GUSATHION (4619) again gave the best results also in these tests. Although mortality was not quite 100 %, the produced effect was nevertheless adequate for the infestation to be satisfactorily suppressed. Practical experience has shown that the plants can be more or less completely freed from infestation by repeating the treatment.

Summary:

Evergreen woody plants and ferns can be rid of scale infestation by treating them once against *Coccus hesperidum* and *Saissetia hemisphaerica* and twice against *Aspidiotus hederae*, with GUSATHION (4619); previously this had not been possible. Past experience has shown that no damage is caused to the plants by the spray, provided the treatment is not carried out in the full glare of the sun.

FOLIDOL OIL

for controlling San José Scale

by W. Philipp, Provincial Institute for Crop Protection, Heidelberg Branch

Apart from the winter spray against San José scale (referred to hereinafter simply as SJS), a practice that continues to form the basis of an effective control of this pest which must still be regarded as a serious threat to crops especially in warm summers, spray applications in spring and summer are also very important. For these, Parathion (also in its formulation as a wettable powder) has proved to be the most effective and reliable active substance. This product becomes active immediately after it is sprayed; the insects are seen to swell, and the scale is raised. Another product recommended for use against this pest is diazinon; experience accumulated in North Baden has shown, however, that other insecticides are not adequately effective to give proper control. In an effort to obtain an even greater increase of the already powerful effect of Parathion, and to bring about a simultaneous control of the green apple aphid (*Doralis pomi* de Geer) which is fairly resistant to Parathion, a large-scale test (covering an area of approx. 1 hectare) was carried out in 1952 at the Heidelberg Branch, using a combination of 1 % summer oil and 0.05 % E 605 forte® which gave absolutely satisfactory control of both SJS and *Doralis pomi*. Thus growers faced with the task of having to combat SJS, welcomed the introduction on the market of oleo-phosphates which, from the toxicological aspect, are no less disadvantageous in their application than most winter sprays. The advantages of these products are obvious: no danger of burns on buds and interplanted crops, no yellow staining as with DNOC or DNBP, no attacking of the skin as caused by tar oils, low concentrations and easy preparation of the spray solution. Growers like to spray oleo-phosphates. A disadvantage is their acute toxicity but provided proper care is taken, this need not be so weighty a factor as the chronic toxicity of dinitro products. It had to be established whether oleo-phosphates can be used for the control of SJS, as winter sprays, as bud-burst sprays or also as summer sprays.

The first trials were conducted with the object of testing the suitability of the products for spray applications during winter dormancy until the beginning of the mouse ear stage. In each test, one or two treatments were carried out on 2 pear bush trees heavily colonized by SJS, using a 0.5 % FOLIDOL Oil spray solution applied by means of a knapsack sprayer (FOLIDOL is the only oleo-phosphoric ester product so far approved by the German Crop Protection Service). The results (Table 1) show that the effect of the product increased as the spray programme continued. The effect produced before and during the winter period may, however, be regarded as satisfactory. FOLIDOL Oil is largely unaffected by the temperatures prevailing at the time of the application but it should not be used at temperatures below freezing point, as demonstrated by the results of the treatment on January 16, 1959. The emulsion breaking effect according to Beran does not therefore, lead to an improvement of the action of FOLIDOL Oil. It must however, be emphasized now that in practice FOLIDOL Oil should be applied as a winter

® = Registered trade-mark of Farbenfabriken Bayer Aktiengesellschaft, Leverkusen.

Table 1:

Date of treatment	Stage of bud development	Mortality in % out of 200 insects		Temp. on day of spraying in °C				General weather conditions on day of treatment
		1st count 27. 4. 59	2nd count 20. 5. 59	max.	min.	mean	during spray application	
24. 11. 58	Winter dormancy	87.7	90.7	5.6	3.2	4.5	5.6	overcast, dry
18. 12. 58	Winter dormancy	88.0	96.3	8.3	3.1	5.4	8	cloudy, dry
16. 1. 59	Winter dormancy	54.4	72.8	-0.9	-10.4	-4.8	-2	snow, ice formation
3. 2. 59	Winter dormancy	98.5	98.5	3.4	-4	0.0	3	foggy, hoar-frost
18. 2. 59	Winter dormancy	95.4	99.5	3.8	-4.4	-1.6	3	foggy, hoar-frost
11. 3. 59	bud swelling	99.1	100	9.8	1.6	6.2	8	cloudy, dry
23. 3. 59	start of mouse ear stage	99.8	99.3	18.1	10.0	12.7	17	cloudy, dry
untreated check trees		30	29.8					
pre-treatment count on								
21. 11. 58		16.7						

spray only when it is to be used solely for controlling SJS. Its effect against other overwintering stages of fruit pests is unsatisfactory when applied in winter.

Table 2:

Date of treatment	Mortality in %	Temp. in °C				Stage of bud development
		max.	min.	mean	during spray application	
5. 3. 1957	100	14.8	-1.0	6.9	12	start of bud swelling
8. 3. 1957	99	13.3	7.4	9.4	8	start of bud swelling
15. 3. 1957	99.5	14.0	3.5	9.0	9	start of bud swelling
2. 4. 1958	98	8.0	-4.9	1.8	8	bud burst
21. 4. 1958	98.3	19.8	4.3	12.4	10	mouse ear stage
24. 4. 1958	100	18.3	-1.0	9.9	13	

The fact that FOLIDOL Oil is unaffected by temperature to a relatively large extent both during and after the application, is proved by the results of the tests given in Table 1, and also by trials conducted in 1957 and 1958. Night frost following the spray did not have any adverse effect nor did it cause damage to buds on pome fruit.

The mortality results in Table 2 also demonstrate the very good effect of FOLIDOL Oil; in some cases these are better than results obtained with the hitherto established winter sprays based on heavy oil, mineral oil, dinitro-cresol and dinitro-butyl-phenol, or their combinations. Oleo-phosphates are, therefore, not winter sprays. Other tests and observations have shown that these products only have a slight ovicidal effect when applied some considerable time before hatching. In our laboratory trials conducted on winter moth eggs, the ovicidal effect was good when the product was applied a few days before hatching. This result coincides with practical experience. A winter, late winter and bud-burst spray* is generally required to produce a versatile effect against the different overwintering stages. This requirement, however, is fulfilled by FOLIDOL Oil from the bud swelling stage to mouse ear. Apart from the good effect against SJS, the product was observed to give appreciable control of bud moth, apple blossom weevil, aphids and winter moth. In a trial control of apple blossom weevil, it was, however, established that the effect largely depends upon correct timing of the application. — An apple orchard on the warm south slope and one on the north slope were sprayed on the same day (April 2, 1959). The check carried out on the trees growing on the north slope — these were not so well advanced in their growth as the trees on the south slope — showed a 50–70 % infestation on untreated trees and a 0.5 % infestation on treated trees. On the south slope, the weevils had already laid a percentage of their eggs. The blossom infestation was recorded at 30 % for treated trees and 50 % for untreated. In both tests, the control of winter moth, aphids, and bud moth (grey) was correctly timed; an infesta-

Table 3:

	1st test 12. 6. 59		2nd test 3. 7. 59		3rd test 18. 7. 59	
	Mortality in % after 20 days	after 30 days	Mortality in % after 37 days	after 46 days	Mortality in % after 16 days	after 30 days
FOLIDOL Oil 0.5 %	77.7	81.6	87.7	91	93.3	88.8
E 605 forte 0.05 %	57.9	61.5	92.7	94	90.4	91.0
untreated	34.7	46.5	43.6	43.4	36.5	36.5
Weather	Mean daily temp: 15° C, cloudy light wind		Mean daily temp: 20.4° C, cloudy light wind		Mean daily temp: 23.6° C, sunny no wind	

* Due to the fact that oleo-phosphates, in contrast to winter sprays, can be sprayed around bud-burst time, they were termed by Engel (Höfchen-Briefe 1958, No. 4) and Bender (Höfchen-Briefe 1959, No. 1) as bud-burst sprays.

tion rating of 2—3 was established for untreated trees, and only a few isolated pests were found on the treated trees.

The application of oleo-phosphoric ester products in spring for pre-blossom spraying has already been dealt with in papers by Bender and v. Rosenberg (Höfchen-Briefe 1959, No. 1). There are of course plenty of other insecticides available for applications in summer, although several tests that were carried out showed that oleo-phosphates give good control of the different stages of SJS on apples and pears also in summer.

The lower effect registered in the 1st test on June 12, 1959 may be attributed to the development stage of SJS at the time of the application, when old females and embryos were chiefly present. The almost ready-to-hatch embryos are apparently more resistant or rather more protected than the black scale stage. FOLIDOL Oil, however, proved more effective than pure E 605 also under these conditions. In these tests, too, no burns were observed either on the sprayed apple and pear trees or on the interplanted crops and weeds. The use of the product as a summer spray may perhaps assume limited importance for application in market gardens to control resistant scale insects or aphids.